

INSTRUCTION MANUAL

QUALITY ASSURANCE
STANDARDS, CALIBRATION, AND
MAINTENANCE LAB.

sweep oscillator

640 SERIES

205



ALFRED ELECTRONICS • STANFORD INDUSTRIAL PARK • PALO ALTO, CALIFORNIA

TELEPHONE: 326-6496 • TWX: 492-9421

ALFRED ELECTRONICS

QUALITY ASSURANCE
STANDARDS, CALIBRATION, AND
MAINTENANCE LAB

TABLE OF CONTENTS

Page Number

Section 1 INTRODUCTION

1.1	Specifications.....	1-1
1.2	Description	1-4

Section 2 OPERATING INSTRUCTIONS

2.1	Front Panel Controls.....	2-2
2.2	Initial Turn-on.....	2-4
2.2.1	Power Requirements.....	2-4
2.2.2	Initial Turn-on Procedures	2-4
2.3	Operating Procedure	2-5
2.4	Remote Frequency Control.....	2-5
2.5	External Leveling.....	2-6

Section 3 CIRCUIT DESCRIPTION

3.1	General.....	3-1
3.2	The Backward Wave Oscillator Tube	3-1
3.3	"+" and "-" 15 Volt Supplies	3-3
3.4	+100 and -50 Volt Supplies.....	3-3
3.5	Cathode Supply.....	3-5
3.6	Anode Supply.....	3-5
3.7	Filament Supply.....	3-5
3.8	Grid Supply.....	3-6
3.9	Sweep Generator.....	3-6
3.10	Sweep Trigger Modes.....	3-6
3.11	Marker Circuit.....	3-7
3.12	Leveling Circuitry.....	3-7
3.13	Modulation Circuitry	3-8

Section 4 MAINTENANCE

4.1	Trouble Shooting.....	4-1
4.1.1	General.....	4-1
4.1.2	No High Voltage with High Voltage Indicator Light Off.....	4-1
4.1.3	No High Voltage with High Voltage Indicator Light On	4-1
4.1.4	No RF Under Any Condition	4-2
4.1.5	RF Not Leveled or No RF Output When RF Output Control is in Leveled Position	4-2

TABLE OF CONTENTS

Page Number

Section 4 MAINTENANCE - continued

4.1.6	Unit Unable to Sweep	4-4
4.2	Test Points	4-4
4.3	Calibration	4-7
4.3.1	Frequency Calibration	4-7
4.3.2	Wide Sweep Calibration	4-7
4.3.3	Marker Calibration	4-9
4.4	Internal Adjustments	4-9
4.4.1	+15 Volt Adjustment	4-9
4.4.2	Overcurrent Relay Trip-out Adjustment	4-9
4.4.3	Backward Wave Oscillator Heater Adjustment	4-11
4.4.4	Backward Wave Oscillator Grid Adjustment	4-11
4.5	Front Panel	4-11
4.6	Backward Wave Oscillator Tube Replacement	4-14
4.7	Frequency and Marker Potentiometer Replacement	4-14
4.8	Warranty	4-17

Section 5 CHARTS AND GRAPHS

Section 6 PARTS LIST

Section 7 SCHEMATICS

SECTION 1 - INTRODUCTION

1.1 SPECIFICATIONS

MODEL	FREQUENCY RANGE	MINIMUM POWER OUTPUT	POWER VARIATION LEVELED	RESIDUAL FM MAXIMUM	VSWR	RF CONNECTOR
641 641K	1 to 2 Gc	70 mw	± 0.5 db	25 Kc peak unleveled. 50 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
641-S1 641K-S1	1.4 to 2.5 Gc	70 mw	± 0.5 db	25 Kc peak unleveled. 50 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
642 642K	2 to 4 Gc	50 mw	± 0.5 db	25 Kc peak unleveled. 50 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
643-S1 643K-S1	3.5 to 6.75 Gc	20 mw	± 0.5 db	60 Kc peak unleveled. 80 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
643 643K	4 to 8 Gc	20 mw	± 0.5 db	60 Kc peak unleveled. 80 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
644 644K	7 to 11 Gc	10 mw	± 0.75 db	75 Kc peak unleveled. 100 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
644-S1 644K-S1	7.0 to 12.4 Gc	10 mw	± 0.5 db	75 Kc peak unleveled. 100 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
645 645K	8 to 12.4 Gc	20 mw	±0.75 db from 8.2 to 12.4 Gc	75 Kc peak unleveled. 100 Kc peak leveled.	Less than 2.5 : 1	UG135/U Flange
646	10 to 15.5 Gc	10 mw		100 Kc peak	Less than 2.5 : 1	W R 7 5 Flange
647	12.4 to 18 Gc	10 mw		100 Kc peak	Less than 2.5 : 1	UG419/U Flange
648	18 to 26.5 Gc	10 mw		250 Kc peak	Less than 2 : 1	UG595/U Flange
649	26 to 40 Gc	5 mw		400 Kc peak	Less than 3 : 1	UG599/U Flange

RF Output:	Model 640 Series; rf output is unlevelled. Rf sampler for external leveling available to 12.4 Gc. Model 640K Series; rf output is either levelled or unlevelled. Rf sampler is internal. Rf sampler for external leveling available to 12.4 Gc.
Frequency Control:	Five controls; F_0 , F_1 , F_2 , M_1 and M_2 continuously adjustable over entire frequency range. All five can be used for single frequency operation and are calibrated to better than 1%.
Frequency Stability:	Better than 0.01% per degree centigrade.
Markers:	M_1 , M_2 and F_0 continuously adjustable over entire frequency range. Markers appear as a reduction in rf power. Amplitude of markers is adjustable to zero. Width is less than 0.05% of frequency range when power reduction is 10% or less.
Wide Sweep: ($F_1 \rightarrow F_2$)	F_1 sets start frequency, F_2 sets end frequency. Width continuously adjustable from 2% to 100% of the full frequency range.
Symmetrical Sweep: ($F_0 \pm \Delta F$)	F_0 sets the center frequency of the symmetrical narrow sweep. ΔF continuously adjustable from 0 to $\pm 5\%$ of the frequency range about any F_0 setting.
Sweep Rate:	Continuously adjustable from 0.01 to 100 seconds per sweep.
Sweep Trigger:	Four modes; EXTERNAL, FREE RUN, LINE and MANUAL (single sweep). A signal of 10 μ sec. duration or longer with an amplitude of at least + 2 volts will trigger the sweep. In LINE mode the sweep is triggered at the input line frequency or a sub-multiple thereof.
Amplitude Modulation:	Three modes; EXTERNAL, OFF and internally generated SQUARE WAVE. Square wave symmetry within 5%. Frequency continuously adjustable between 800 and 1200 cps. Rise time is less than 15 μ sec. levelled, less than 1 μ sec. unlevelled.

External +10 volt signal turns on rf to level determined by power level control. Input impedance is 10 K Ω . Rise time is less than 15 μ sec. leveled, less than 1 μ sec. unleveled. Input is dc coupled.

External positive signal can give rise times of less than 0.5 μ sec. in unleveled pulse mode. The signal modulates the grid of the backward wave oscillator from cutoff to maximum power. Input impedance (pulse) is approximately 5 K Ω shunted by 100 pf. Input is dc coupled to the modulator and ac coupled to the grid of the backward wave oscillator. Amplitude of signal depends on backward wave oscillator grid characteristics; 75 volts is maximum required. (Most bands require approximately 25 volts.)

Frequency Modulation:

Externally applied signal of 1.5 volts, peak to peak, produces a 10% deviation of full frequency range. Positive going voltage increases frequency. FM can be applied during all modes of operation. Response; dc to 10 Kc. Input impedance; 15 K Ω .

Leveler Input:

-100 mv into 3 K Ω required for rated rf output.

Sweep Output:

Zero to 15 volts sawtooth during $F_1 \rightarrow F_2$ and $F_0 \pm \Delta F$ sweep modes. Zero to 15 volt dc signal depending upon frequency setting when operating at F_0 , M_1 or M_2 in the SINGLE FREQUENCY mode. Output impedance is 10 K Ω .

Blanking Output:

A +50 volt signal is available during sweep retrace. Output impedance is 10 K Ω .

Recorder Calibrate:

A +15 volt signal is available at the SWEEP OUTPUT jack when the RECORDER CALIBRATE button is depressed.

Power Level:

In LEVELED mode the power level is adjustable over a 10 db range. In UNLEVELED mode the power level is continuously adjustable from zero to maximum tube capability.

Power Input:

105 to 125 volts or 210 to 250 volts; 50/400 cps; 150 VA.

Dimensions:

See Figure 1-1.

Weight:

Approximately 60 pounds.

1.2 DESCRIPTION

The ALFRED 640 Series Sweep Oscillator is a general purpose microwave signal source utilizing a voltage tuned backward wave oscillator tube. The tube is powered by low drift, low ripple, precisely regulated power supplies.

The rf output can be modulated by either an externally applied am or fm signal or by an internally generated square wave. The square wave frequency is continuously adjustable from 800 to 1200 cps. An externally generated pulse can be capacitively coupled to the backward wave oscillator grid for fast am rise time.

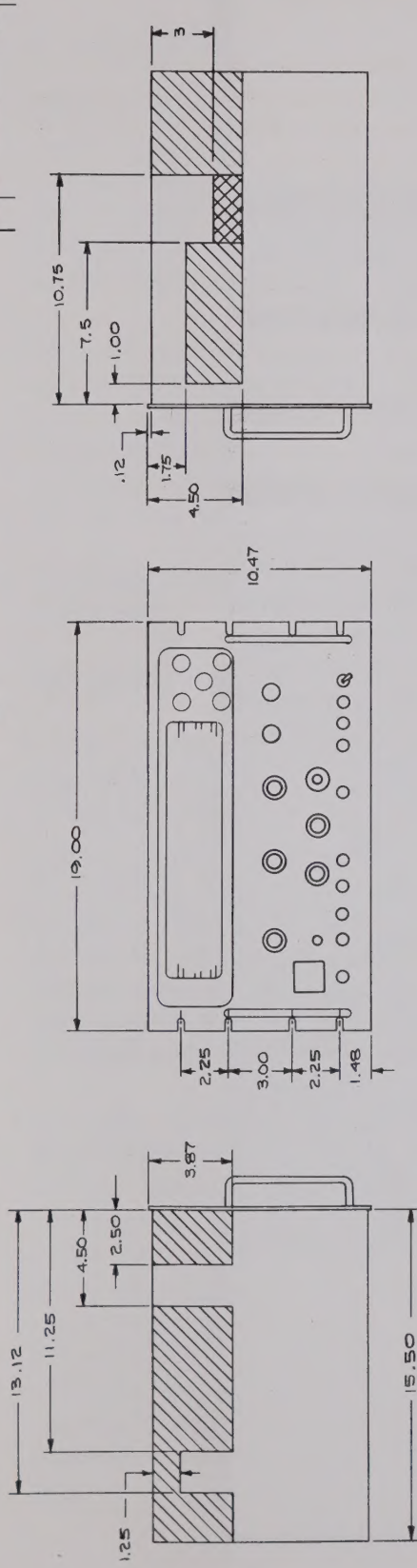
Leveling of the rf output is accomplished by a closed loop circuit. A crystal diode supplies a voltage which is proportional to the rf power. This voltage is compared to a stable dc reference voltage. The difference, or error voltage, is then amplified and applied to the grid of the backward wave oscillator so that power output variations can

be continuously corrected.

Three frequency markers are provided. They are short, triangular, negative pulses which modulate the rf. The pulse width is less than 0.05% of the total frequency range and the amplitude is adjusted by a front panel control.

For X-axis drive of oscilloscopes and recorders, a linear, positive going 15 volt sweep voltage is available. A front panel push button provides the +15 volt signal in all modes of operation for end point reference. A +50 volt signal is available for recorder pen blanking while a front panel control selects rf on or off during sweep retrace.

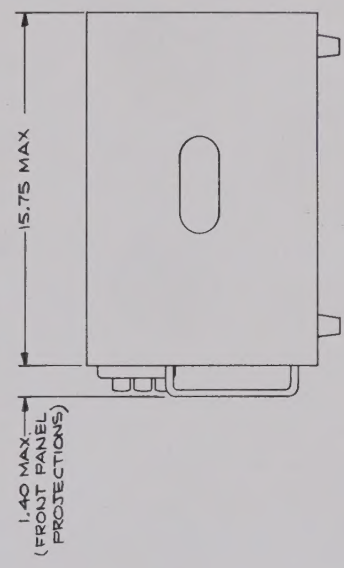
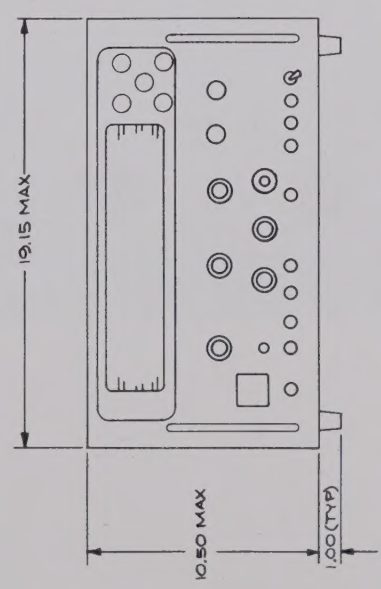
The backward wave oscillator tube used in the 640 does not require rf adjustment, is encapsulated for protection, and is easily replaced. Test points are provided on the rear of the unit to monitor electrode currents and voltages. Protective circuits reduce the likelihood of damage to the tube.



LEFT SIDE

RIGHT SIDE

INSTRUMENT WITH SIDE PANELS REMOVED
(FOR RACK MOUNTING) - SEE LEGEND



LEGEND

- AREA WHERE CHASSIS TRACK MOUNTING HOLES MAY BE LOCATED FOR ALL MODELS.
- AREA AVAILABLE FOR NON-SOLENOID MODELS BUT NOT AVAILABLE FOR SOLENOID MODELS.

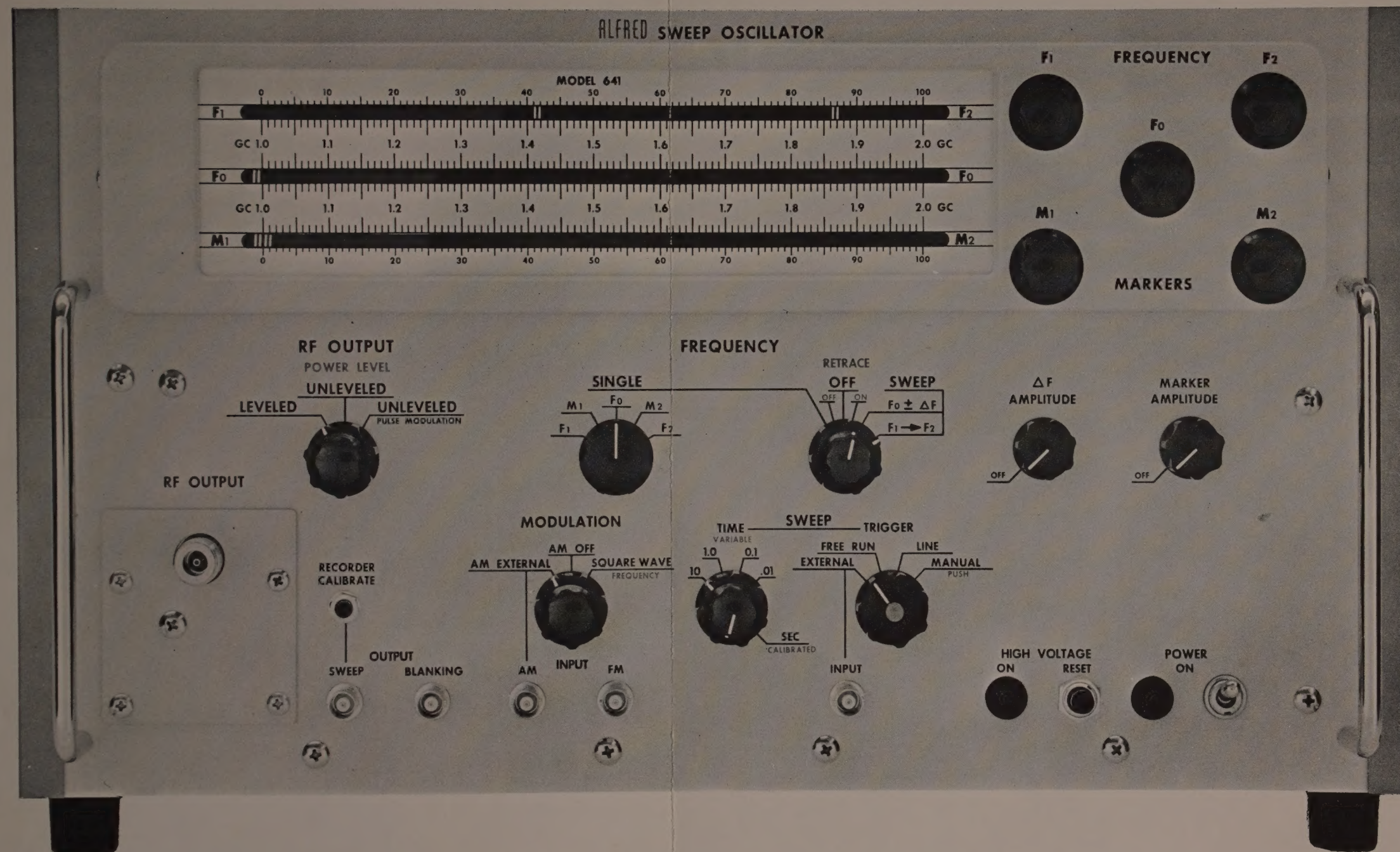
INSTRUMENT WITH SIDE PANELS INSTALLED

FIGURE 1-1

- NOTES:**
1. THE MODEL 640 SERIES INSTRUMENT MAY BE EITHER BENCH MOUNTED OR RACK MOUNTED.
 2. FOR RACK MOUNTING REMOVE BOTH SIDE PANELS.
 3. FOR INSTALLATION OF CHASSIS TRACKS, DRILL MOUNTING HOLES ONLY IN SHADDED AREAS INDICATED ABOVE.
 4. APPROXIMATE WEIGHT OF INSTRUMENT IS 60 LBS. (SLIGHTLY HEAVIER FOR SOLENOID MODEL INSTRUMENTS).

ITEM	RECD	PART NO.	DESCRIPTION
MATERIAL			OUTLINE & DIMENSIONAL DATA FOR MODEL 640 SERIES INSTRUMENT
ENGINEER			DATE
DESIGNED BY			
CHECKED BY			
FINISH OR TREATMENT			
SCALE			1:4

640 SERIES	USED ON
NEXT ASSY	
ALFRED ELECTRONICS PALO ALTO, CALIFORNIA	
990125C	
SHEET 1	OF 1



FRONT PANEL
FIGURE 2-1

SECTION 2 - OPERATING INSTRUCTIONS

2.1 FRONT PANEL CONTROLS

A. **FREQUENCY CONTROLS:** Located to the right of the calibrated dial are three frequency controls: F_1 , F_0 , and F_2 . They are used in conjunction with the three frequency indicators and the calibrated dial to set the desired frequencies.

B. **MARKER CONTROLS:** Below the three frequency controls are two marker controls: M_1 and M_2 . They are used in conjunction with the two marker indicators and the calibrated dial to set the desired marker frequencies. In the $F_1 \rightarrow F_2$ mode, F_0 is also a marker.

C. **FREQUENCY MODE SELECTOR - RETRACE CONTROL**

FREQUENCY MODE SELECTOR

$F_1 \rightarrow F_2$: In this position the rf output is swept from the F_1 frequency indicator setting to the F_2 frequency indicator setting. The sweep frequency range (from F_1 to F_2) can be varied from 100% to 2% of the frequency band of the oscillator. When in this mode marker pips are provided at the F_0 , M_1 and M_2 frequency settings and a sawtooth sweep voltage of 15 volts amplitude is available at the SWEEP OUTPUT jack.

$F_0 \pm \Delta F$: In this position the rf output is swept symmetrically about any F_0 frequency setting. ΔF can be varied from 5% of the band to zero. The $F_0 \pm \Delta F$ mode can be used to examine small perturbations seen when using the $F_1 \rightarrow F_2$ mode. To do this set the F_0 marker pip at the perturbation frequency and change the mode from $F_1 \rightarrow F_2$ to $F_0 \pm \Delta F$. When in this mode, marker pips are provided at the M_1 and M_2 frequency settings and the 15 volt sawtooth is available at the SWEEP OUTPUT jack.

OFF: When in this position the backward wave oscillator is biased off and no rf appears at the output. In single frequency operation the OFF position is used to zero external meters and establish a zero power reference. If the instrument is to be left on but in a standby condition the FREQUENCY mode selector should be in the OFF position.

SINGLE: In this position the oscillator output can be one of five single frequencies determined by the F_0 , F_1 , F_2 , M_1 or M_2 indicators. The SINGLE FREQUENCY switch determines which frequency indicator controls the output frequency.

In both the F_1 and F_2 positions a voltage is provided at the SWEEP OUTPUT jack. In the F_1 position zero volts is provided while at F_2 +15 volts is provided. These voltages can be used to set the start and end points of oscilloscopes and recorders. In the F_0 , M_1 and M_2 positions, a voltage is provided at the SWEEP OUTPUT jack which is a function of the frequency and can be used to control the X-axis of X-Y recorders.

D. **RETRACE CONTROL:** Concentric with the FREQUENCY mode selector, this control is operative only in the SWEEP modes, i. e., $F_0 \pm \Delta F$, $F_1 \rightarrow F_2$. In the OFF position, the rf is off during retrace.

E. **RF OUTPUT CONTROL:**

LEVELED: In this position the rf output is maintained constant across the frequency band. The output level is set by the concentric POWER LEVEL control and has a 6 db control range.

UNEVELED: In this position the rf output can be adjusted from zero to maximum tube capability at any point in the band by the POWER

LEVEL control. Since the maximum leveled output is generally less than the tube capability, this mode allows more rf output than the LEVELED mode.

UNLEVELED - PULSE MODULATION: In this position the rf can be modulated by an external signal applied through the AM INPUT jack. The signal is capacitively as well as dc coupled to the backward wave oscillator grid and allows fast rise time. The rf signal is unaffected by the POWER LEVEL control and remains at its maximum output level.

F. MODULATION CONTROL

AM EXTERNAL: When in this position and the RF OUTPUT control is in the LEVELED or UNLEVELED position, a positive 10 volt signal applied to the AM INPUT jack will turn the rf on to the level set by the POWER LEVEL control. When the RF OUTPUT control is in the UNLEVELED PULSE mode, a positive signal whose magnitude depends upon the BWO tube used turns the rf on to maximum power.

AM OFF: When in this position, the rf output is unmodulated.

SQUARE WAVE: In this position the rf output is modulated by an internally generated square wave whose frequency can be varied between 800 and 1200 cycles per second by the SQUARE WAVE FREQUENCY control which is concentric with the MODULATION control.

G. SWEEP TIME CONTROL: This control sets the time to sweep from the start frequency (F_1) to the end frequency (F_2) while in the $F_1 \rightarrow F_2$ sweep mode and the time to sweep from $F_0 - \Delta F$ to $F_0 + \Delta F$ in the $F_0 \pm \Delta F$ sweep mode. There are four major settings: .01, 0.1, 1.0 and 10 seconds. A concentric

knob allows continuous intermediate settings up to 100 seconds. When the concentric knob is full clockwise, the sweep time is calibrated to the value indicated by the SWEEP TIME control.

H. SWEEP TRIGGER CONTROL

EXTERNAL: When in this position, a positive signal applied to the EXTERNAL TRIGGER INPUT jack will trigger the sweep. The amplitude must be at least +2 volts and the width at least 10 microseconds.

FREE RUN: In this position the sweep is triggered immediately upon the completion of a cycle.

LINE: In this position the sweep trigger is synchronized to the input line frequency or a sub-multiple of the line frequency, depending upon the setting of the sweep time control.

MANUAL: In this position the sweep is triggered by pressing the concentric button.

I. ΔF AMPLITUDE CONTROL: This control varies the width of the symmetrical sweep about F_0 when the FREQUENCY mode selector is in the $F_0 \pm \Delta F$ mode. In full clockwise position the width is at least $\pm 5\%$ of the frequency band.

J. MARKER AMPLITUDE CONTROL: This control sets the amplitude of the marker pulses that are visible in the swept rf output. The type of circuit used results in a pulse whose width is also reduced as the amplitude is reduced.

K. HIGH VOLTAGE RESET: If for some reason the helix current limitation of the backward wave oscillator is exceeded, the high voltage will automatically turn off. If correct adjustments are made and the reset button is pressed, high voltage will be restored.

L. RECORDER CALIBRATE BUTTON: A +15 volt signal is available at the SWEEP OUTPUT jack when the RECORDER CALIBRATE button is depressed. This signal is available in all modes and is used to set up recorders and oscilloscopes. At the start of any sweep, the sweep output is always zero volts and at the end of any sweep, it is always +15 volts.

2.2 INITIAL TURN-ON

2.2.1 POWER REQUIREMENTS

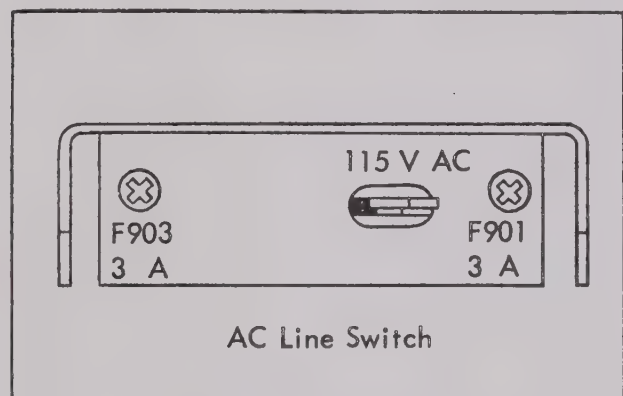


Figure 2-2

The unit is normally connected at the factory for operation at 105 to 125 volts and 50 to 400 cycles ac (115 volts nominal). However, provisions are made for easy conversion to operation at 210 to 250 volts, 50 to 400 cycles ac (230 volts nominal). With the top cover removed, locate the power switch plate labeled 115 VAC. (See Figure 2-2.) By removing and reversing this plate, the switch can be moved to the left. Replace the plate with 230 volts ac showing. Replace the eight ampere main fuse (in back of instrument) with a six ampere fuse.

2.2.2 INITIAL TURN-ON PROCEDURES

Prior to regular operation of the unit, the following test should be performed:

1. Set FREQUENCY mode selector to SINGLE; F_0 .
2. Set FREQUENCY indicator F_0 to the low end of the scale (0 on logging scale).
3. Set MODULATION control to AM OFF.
4. Set RF OUTPUT to UNLEVELED and rotate the POWER LEVEL control to the maximum CW position.
5. Connect a millivoltmeter to TP18 and TP19 located in the rear of the instrument. These test points are calibrated to supply 10 mv/ma into a load greater than 1 K. Move switch S913, located below TP18 and TP19, to the HELIX/DELAY LINE position.
6. Turn power switch to ON.

NOTE: Time delay relays delay high voltage turn on for approximately 60 seconds after the POWER switch is turned ON to allow a brief warm up period for the backward wave oscillator filament. If the AC power is off for only an instant, the normal 60 second delay will occur before high voltage returns.

7. When the high voltage appears, measure the helix current on the meter. The helix current should be less than that specified in Chart #1, Section 5. Move switch S913 to the COLLECTOR position. Observe the collector current. The value should be between 5 and 15 ma. (For acceptable values see tube data sheet located in envelope at rear of manual.)
8. With tubes that have delay lines (no collector) switch S913 should be set to the HELIX/DELAY LINE position. Current values of these tubes should be between 10 and 40 ma.
9. The collector or delay line current can vary from instrument to instrument and therefore no definite value is established. (See tube data

sheet, located in envelope at rear of manual for complete data on the tube in your instrument.) If the backward wave oscillator currents are correct, the unit is ready for operation.

2.3 OPERATING PROCEDURE

Turn POWER switch to ON. After high voltage appears, the instrument is ready for operation.

For wide sweep operation, the FREQUENCY mode selector is set to $F_1 \rightarrow F_2$ and the F_1 and F_2 FREQUENCY indicators are set to the desired start and end frequency points. The SWEEP TIME and SWEEP TRIGGER controls are adjusted to the desired time and trigger conditions.

For narrow sweep operation the FREQUENCY mode selector is set to SWEEP; $F_0 \pm \Delta F$ and the F_0 FREQUENCY indicator is used to set the desired frequency.

The ΔF AMPLITUDE control can be adjusted to the $\pm \Delta F$ sweep width desired. A maximum value of at least $\pm 5\%$ of the frequency band of the instrument is available.

Example: Frequency band of instrument = 2 to 4 Gc
 Band Coverage = 2 Gc
 5% of 2 Gc = 100 Mc (maximum ΔF)

When sweeping in either the wide or narrow sweep modes, markers are available by turning up the MARKER AMPLITUDE control. In the $F_1 \rightarrow F_2$ mode there are three markers available whose frequencies are set by the F_0 , M_1 , and M_2 control knobs. In the $F_0 \pm \Delta F$ mode two markers are available: M_1 and M_2 .

During either wide or narrow sweep a sawtooth waveform whose amplitude is + 15 volts peak is provided at the SWEEP OUTPUT jack. Also provided is a + 50 volt pulse at the BLANKING OUTPUT jack which occurs during retrace and is controlled by the concentric RETRACE control.

For single frequency operation the FREQUENCY mode selector can be set to SINGLE; F_0 , F_1 , F_2 , M_1 or M_2 and the frequency desired set by the F_0 ,

F_1 , F_2 , M_1 or M_2 control knob. For manual sweep, the FREQUENCY mode selector is set to SINGLE; F_0 and the F_0 control knob is used to sweep the frequency manually. During manual sweep a dc voltage which is a function of the F_0 frequency is available at the SWEEP OUTPUT jack.

The rf power output can be either leveled, un-leveled or unlevelled-pulse modulated by selecting the applicable mode with the RF OUTPUT control. The LEVELED mode provides a constant rf power output across the frequency band, whereas, in the UNLEVELED mode the rf power output can be adjusted from zero to maximum tube capability by the concentric POWER LEVEL control.

2.4 REMOTE FREQUENCY CONTROL

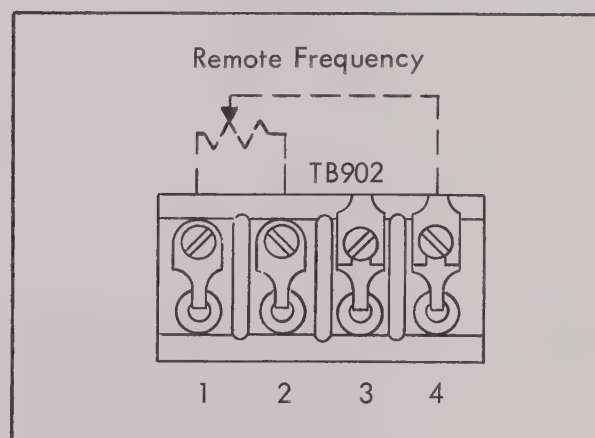


Figure 2-3

If it is desired to control the F_0 FREQUENCY at some distance from the instrument, terminal block TB902, located at the rear of the instrument, is provided for this purpose. See Figure 2-3.

Remove the jumpers at TB902, -3 and -4 and insert a 1 K Ω potentiometer as indicated by the dotted lines.

NOTE: Shielded wires should be used to connect the external 1 K Ω potentiometer to the terminal. (A shielded three wire cable is satisfactory.)

2.5 EXTERNAL LEVELING

External leveling of the rf output is used advantageously when the load to be tested cannot be connected directly to the 640 unit. By locating the rf sampler at the load, transmission line and component discontinuities are contained within the leveling loop and are compensated. When more power is required, a microwave amplifier can be included inside the leveling loop.

The Model 640 Series Microwave Oscillator may be externally leveled by sampling the signal from the rf output and applying the detected signal to the INPUT LEVELER jack. This signal should be approximately -100 mv.

The Model 640K Series Microwave Oscillator is internally leveled. The installation of "Option 7" provides the additional capability for external leveling. External leveling is accomplished by sampling the signal from the rf output and applying the detected signal to the INPUT LEVELER jack. This signal should be approximately -100 mv.

SECTION 3 - CIRCUIT DESCRIPTION

3.1 GENERAL

See Block Diagram, Figure 3-12.

The high frequency rf energy produced by the unit is generated by a backward wave oscillator tube. The tube is controlled by stable power supplies. Through proper voltage control the backward wave oscillator provides a means of producing either a variable frequency (sweep mode) or a stable frequency (single mode).

The rf output frequency of the backward wave oscillator tube is primarily determined by the voltage difference between its cathode and helix. Since the tube helix is grounded through a small value resistor, the cathode supply determines the rf output frequency. The backward wave oscillator can be operated continuously at a fixed frequency or may be repeatedly swept over any part of its operating frequency range. An internal sweep generator, whose ramp output drives the cathode supply, provides this sweeping feature. Since the backward wave oscillator frequency vs. cathode voltage function is non-linear, the cathode supply is made non-linear so as to make the output frequency a linear function of the sweep voltage.

Because the power output of the backward wave oscillator varies over its frequency range, a leveler system is used to hold the rf power output constant. The unit can also be operated unlevelled to obtain the maximum power output of the tube.

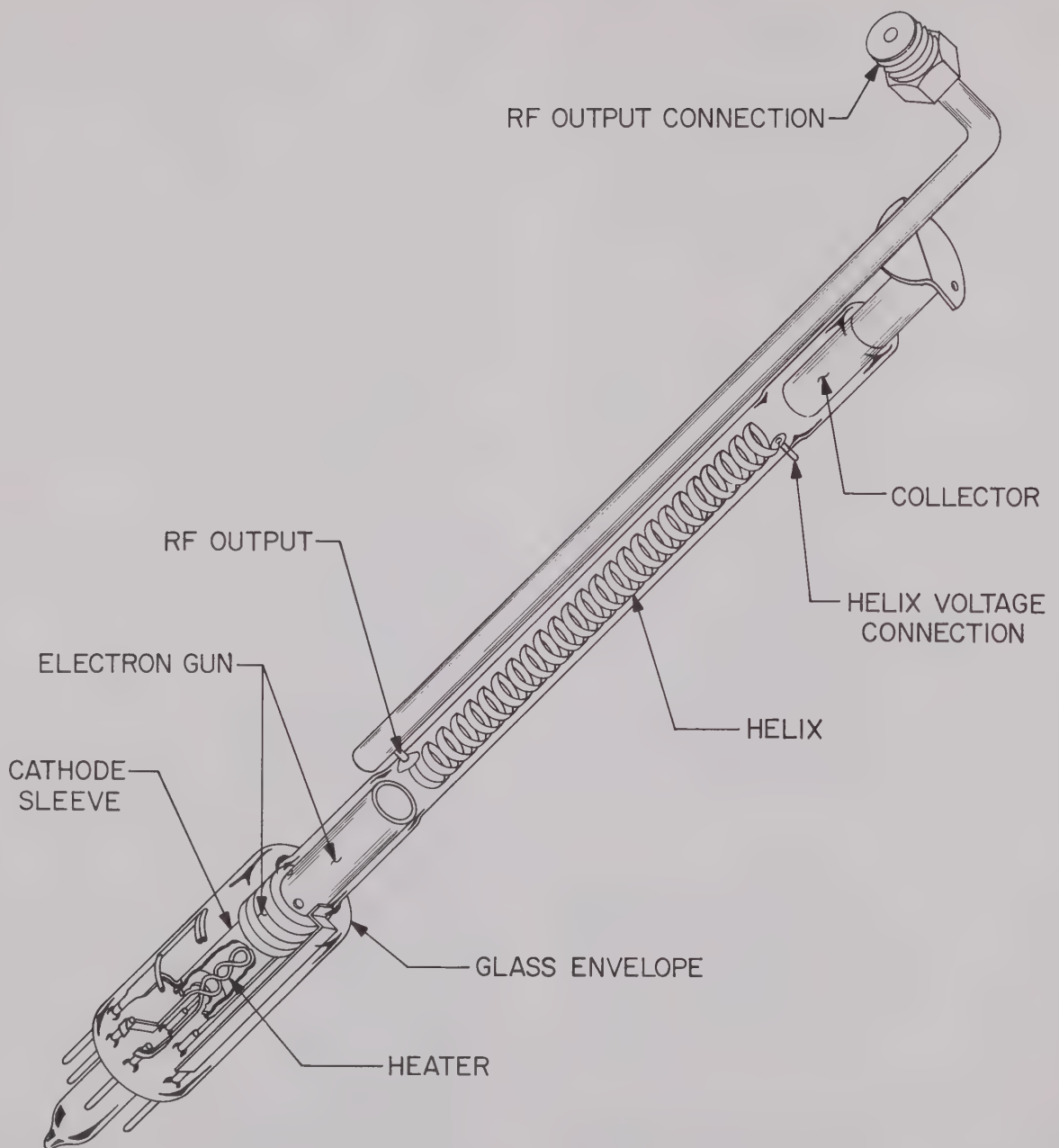
3.2 THE BACKWARD WAVE OSCILLATOR TUBE

The backward wave oscillator tube consists of an electron gun, a slow wave structure and a collector at the far end of the slow wave structure. The rf output of the tube is produced by the interaction between the electron beam and the electromagnetic field of a microwave signal developed on

the slow wave structure. See Figure 3-1.

The electron gun contains a heated cathode and two or more aperture disc type control electrodes which help form the beam and control beam density. In a helix backward wave oscillator, it is desirable to have a hollow cylindrical electron beam since only the electrons that pass adjacent to the helix are fully effective in delivering energy to the wave. Electrons near the middle of the beam consume anode power but contribute little or nothing to the energy interchange that produces the backward wave oscillations. Surrounding the tube is a magnet which produces a strong axial field. This field focuses the electrons in the beam and allows movement only in the direction of the axis of the tube.

Oscillations, and hence the rf wave, begin in the backward wave oscillator in much the same manner as they begin in other oscillators. Noise waves are established on the helix from the shot noise coupled from the electron beam and from thermal energy developed at the input end of the tube. Waves are produced which travel in both directions in the helix, i. e., from gun to collector and from collector to gun. Since the desired wave in a backward wave oscillator must travel from the collector to the gun end, attenuators are placed in the tube which eliminate the forward moving waves. Amplification of the wave is produced by the interaction of the electrons in the beam and the electromagnetic field of the wave. To obtain this interaction, the electron beam must be at some critical velocity which is achieved by applying a dc voltage to the helix. Because the electromagnetic field is alternating, electrons in the beam are subjected to either an accelerating or decelerating field. Thus, the electrons entering the helix experience velocity modulation with a tendency for a bunch of electrons to be formed as they move through the helix. The critical areas of interaction are the spaces between the helix turns because the



BACKWARD WAVE OSCILLATOR TUBE
FIGURE 3-1

axial electric field is strong between helix turns and weak under the turns.

To explain the bunching process let us examine a group of electrons as they travel from the gun to the collector end of the tube. Within this group there will be one electron, e , which corresponds to the zero point of the alternating axial field and is therefore unaffected by the signal on the helix. See Figure 3-2A. This electron experiences no acceleration from the electromagnetic field. However, an electron just to the left of e , e' , encounters a positive axial field and is accelerated thus tending to catch up with e . Similarly, electron e'' , which is just to the right of e , encounters a negative or decelerating field and so slows down and tends to be overtaken by electron e . The electrons centered about e are thus velocity modulated. This situation is repeated over and over again as the electrons centered about the reference electron pass one space after another. Now, by choosing the electron velocity so that at the collector end of the tube the phase difference between the wave and bunches in the beam is approximately one half cycle, the electron bunches will encounter relatively strong decelerating fields as they cross the spaces. Thus, the kinetic energy of the electrons is transferred to the backward wave. The amplitude of the backward wave builds up as it progresses toward the gun end of the tube because it passes more and more bunches from which it receives energy. At the same time, the alternating component of the beam current, i. e., the bunching becomes greater as the electrons progress toward the collector. See Figure 3-2B.

The operating frequency range of a particular backward wave oscillator tube is primarily determined by the dimensions of the slow wave structure. Since the most commonly used slow wave structure is a helix the following discussion will be based on this type of tube.

It is well known that a slow wave structure will

propagate a particular range of frequencies at constant axial velocity (the non-dispersive region) and above that range, the axial velocity of propagation increases with frequency (the dispersive region). The backward wave oscillator operates in the dispersive region and it will oscillate at the frequency for which the beam velocity is very nearly equal to the axial velocity of propagation. Figure 3-2C shows the variation of propagation velocity with frequency for a particular helix while Figure 3-2D shows how the beam velocity varies with the helix to cathode voltage.

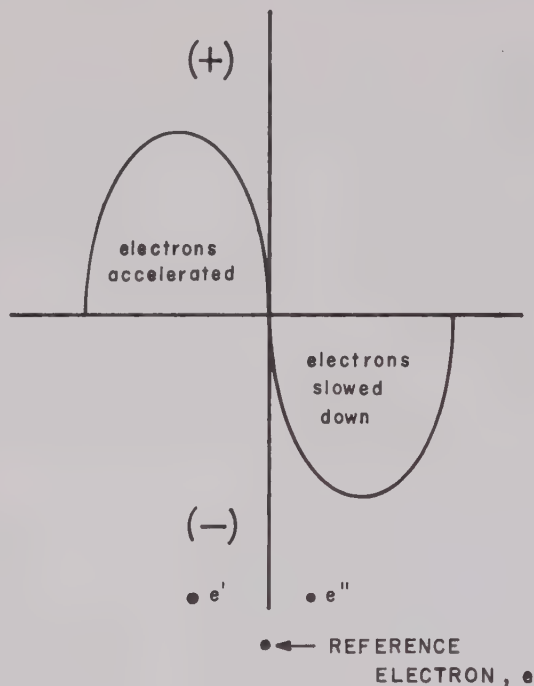
From these figures it can be seen why the backward wave oscillator can be voltage tuned. By changing the helix to cathode voltage, the beam velocity changes and the frequency for which the velocity of propagation and the velocity of the beam are in synchronism changes. The helix dimensions, primarily diameter and pitch, are chosen so that the tuning voltages required for a particular frequency range are reasonable (usually about 200 to 2000 volts).

3.3 "+" and "-" 15 VOLT SUPPLIES

The + and -15 volt power supplies provide the reference voltages for the unit. See Figure 3-3. To provide the stability required, three stages of amplification and a series regulator are used for each supply. By referencing the -15 volt supply to a temperature compensated zener diode, CR201, voltage variations which normally accompany temperature changes are practically eliminated. To compensate for zener diode voltage tolerances, the -15 volt supply can be adjusted by means of R214 located on PC Board 200. The +15 volt supply is referenced to the -15 volt supply.

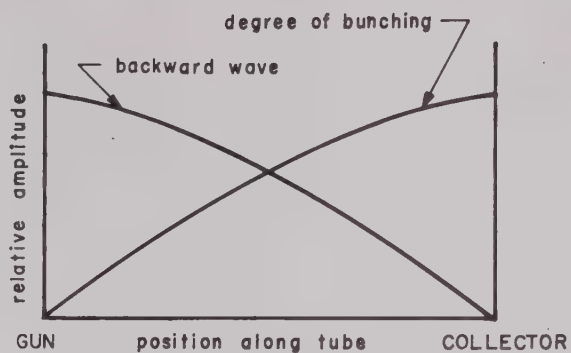
3.4 +100 and -50 VOLT SUPPLIES

In addition to the + and -15 volt supplies, there are two other low voltage sources: the +100 and -50 volt power supplies. See Figure 3-4. Both supplies use a single stage transistor amplifier driv-



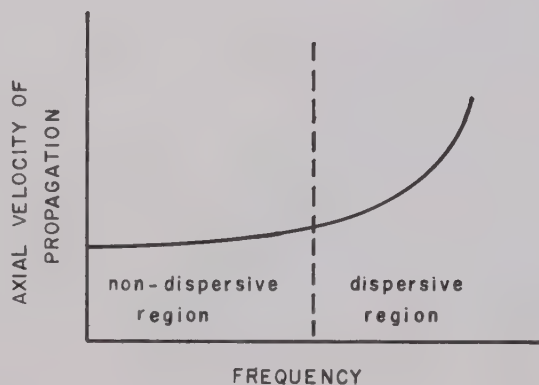
ELECTRON DISTRIBUTION

(A)



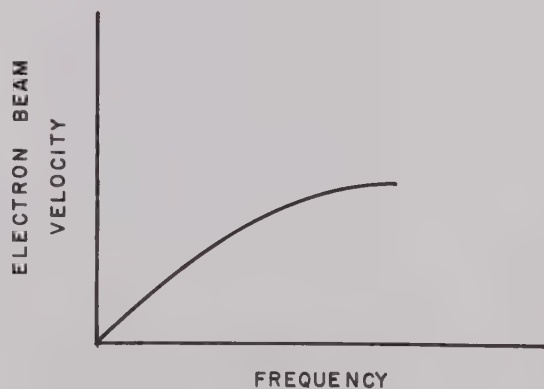
RELATIVE AMPLITUDE VS.
POSITION ALONG TUBE

(B)



AXIAL VELOCITY OF PROPAGATION
VS. FREQUENCY

(C)



ELECTRON BEAM VELOCITY
VS. FREQUENCY

(D)

ing a series regulating transistor. All transistors in the -50 volt supply are located on PC Board 200 while the regulating transistor for the +100 volt supply is located on the main chassis. The +100 volt supply is referenced to the -15 volt supply and the -50 volt supply to the +15 volt supply. As they are auxiliary supplies, they need not be regulated as closely as their references.

3.5 CATHODE SUPPLY

The cathode supply for the backward wave oscillator is an operational amplifier using both tubes and transistors. See Figure 3-5. It consists of a summing junction and a transistorized operational amplifier which controls the grids of the series regulator tubes V901, V902 and V903, located in the rear of the instrument. The summing junction and the operational amplifier are located on PC Board 100. The summing junction is at the base of Q101. A portion of the dc output is fed into the input of the summing junction, through high impedance emitter followers Q109 and Q110, forming a complete feedback system whose output can range from 150 to 2500 volts. The high impedance path makes it unnecessary to use high power resistors, thus minimizing power dissipation and hence thermal drift. Two diodes, CR101 and CR102, are used to compensate for any temperature deviations which occur in the emitter followers. Also in the feedback network is a non-linear, voltage sensitive attenuator consisting of a diode shaping network located on PC Board 900. It causes the output of the cathode supply to become non-linear with respect to its input and thus compensates for the non-linear tuning curve of the backward wave oscillator. Hence, the output frequency is directly proportional to the input voltage of the amplifier. For single frequency operation a voltage directly proportional to the frequency dial indicator position is applied to the amplifier input. During $F_1 \rightarrow F_2$ swept operation a linear varying voltage, supplied by the sweep generator, is applied to the amplifier input. When in the $F_0 \pm \Delta F$ sweep mode a linearly varying voltage, supplied by the sweep generator,

starts at $F_0 - \Delta F$ and sweeps to $F_0 + \Delta F$. This sweep voltage is applied to the amplifier input. The external modulation input is also connected to the amplifier input. A 1.5 volt signal will change the frequency by 10% of the band.

Tubes are used as the control elements for the high voltage supply because of their ability to withstand the high voltage required for the cathode of the backward wave oscillator. Transistors were chosen for the preamplifier because of their immunity to microphonics and low power requirements.

3.6 ANODE SUPPLY

The gun structure of all backward wave oscillators contains an anode which collimates the electron beam before it is accelerated to helix potential. The anode operates at an elevated potential with respect to the cathode and may vary from 25 to 250 volts depending upon the tube type. See Figure 3-6. Supply regulation is accomplished by a shunt regulator circuit consisting of one vacuum tube, which serves as the shunt regulator element, and three transistors. The transistor amplifier drives the shunt regulator tube and is located on PC Board 800. A reference voltage is furnished by the 70 volt grid bias supply. The anode voltage is adjusted by means of R828, the ANODE VOLTAGE ADJUST potentiometer and R831; a coarse adjustment made by changing its value.

3.7 FILAMENT SUPPLY

The filament supply is a regulated, variable, dc supply using a series regulator transistor and a two stage transistor amplifier. See Figure 3-6. The regulator amplifier, consisting of Q801 and Q802, is located on the elevated supplies board, PC 800. A zener diode, CR801, is the supply reference. The output voltage may be adjusted by means of R805, the backward wave oscillator HEATER VOLTAGE ADJUST, located on PC Board 800.

3.8 GRID SUPPLY

The 70 volt grid supply furnishes power to the grid driver amplifier. See Figure 3-6. It is shunt regulated and uses a two stage transistor differential amplifier to drive the shunt regulator transistor, Q803. A zener diode reference, CR802, is used to determine the supply output. Most of the components of this supply are located on PC Board 800.

3.9 SWEEP GENERATOR

The sweep generator is located on PC Board 300 and PC Board 700. The four basic circuits on PC Board 300 are the Miller integrator consisting of Q304-Q307, the trigger circuitry consisting of Q308-Q311, a gating multivibrator consisting of Q301-Q302, and a retrace hold-off circuit consisting of Q312-Q314. See Figure 3-7.

The basic part of the sweep generator is the Miller integrator, a capacitive feedback dc amplifier which integrates its input voltage producing a linearly increasing output. This linear output creates a ramp which is used as the sweep in the instrument. The feedback capacitors for the Miller integrator are C701-C704, located on PC Board 700. The slope of the ramp output of Q307 is determined by the feedback capacitors and resistors R945 and R946.

Prior to the initiation of the sweep, Q301 in the multivibrator is off causing a positive voltage to be fed to the base of Q314. This causes the output of the retrace hold-off circuit Q312 to be positive which places a positive voltage on the base of Q304, the input to the Miller integrator circuit. This holds the output of the Miller integrator circuit, the collector of Q307, at approximately zero volts. A positive trigger applied to the base of Q309, through resistor R319, causes the Schmitt trigger, Q310 and Q311, to switch. The resulting negative spike on the collector of Q311 is fed to the base of Q302 in the multivibrator, through S906, causing the multivibrator to change states. Q302 is now off, or in the non-conducting state,

while Q301 is on, or in the conducting state. This causes positive voltage to be removed from the base of both Q314 and Q304. The Miller integrator now generates a ramp function determined by the setting of switch S903, which selects the feedback capacitor and by the adjustment of R946, the SWEEP TIME multiplier control. When the ramp output of Q307 reaches 40 volts, CR302 becomes forward biased placing a positive voltage on the base of Q302, causing the multivibrator to change states. A positive voltage is again applied to the Miller integrator input, through the retrace hold-off circuit, causing the feedback capacitor to rapidly discharge. The Miller integrator output returns to zero volts. Thus, the sweep completes one cycle of operation and is ready for another. The sweep output from Q307 is channeled to the frequency controls through emitter follower Q705. The output of Q705 is also connected to emitter follower Q704, which in turn is connected to the SWEEP OUTPUT jack, J915.

In addition to the ramp output, this circuitry also provides a blanking voltage generated at the collector of amplifier Q303. The input to Q303 is taken from the collector of Q302 in the gating multivibrator circuit. Q303 amplifies the multivibrator output producing a +50 volt pulse which occurs during retrace and can be used for recorder pen lift or for oscilloscope blanking.

3.10 SWEEP TRIGGER MODES

The Model 640 provides four means of initiating or triggering a sweep. The choice is provided by the front panel SWEEP TRIGGER control whose four positions are FREE RUN, EXTERNAL, LINE and MANUAL. In the FREE RUN position the sweep is self-triggered. When the sweep returns to zero volts CR301 conducts, causing the sweep gate multivibrator to flip into the opposite condition, immediately retriggering the sweep cycle. In the EXTERNAL mode, transistors Q310 and Q311 form a Schmitt trigger which takes any arbitrary input waveform and transforms it into a step function.

The step function is differentiated and the resultant spike is fed to CR301 to trigger the sweep. In the LINE mode a 6.3 volt ac rms voltage, at the line frequency, is supplied to the Schmitt trigger thus synchronizing the sweep rate to the power line frequency. In the MANUAL mode the push-button switch connects the Schmitt trigger to the +15 volt supply and allows just one trigger each time the button is depressed.

3.11 MARKER CIRCUIT

Located on PC Board 400, the marker circuit is shown schematically on Figure 3-8. For simplicity, only one of the three identical channels is shown. The marker circuit provides wavemeter-like pips to indicate preset frequencies set by the F_0 , M_1 or M_2 FREQUENCY control knobs. The markers are electronically generated from the sweep. A voltage is summed into the markers by the marker adjusting potentiometers M_1 , M_2 or F_0 . The signal applied to the input of the cathode supply is also applied to the marker input. The marker has a condition which depends upon the backward wave oscillator beam voltage or the oscillating frequency of the backward wave oscillator as related to its input voltage. Hence, the same total current is summed into the helix supply and the action of the markers is identical in character to the helix supply. Thus, the marker generated is directly related to the frequency of oscillation of the backward wave oscillator tube.

A marker will appear when the input current corresponding to the frequency of oscillation is balanced by the current from the marker potentiometer. The first three stages of the marker circuit are amplifiers. The fourth stage is a high gain differential amplifier which is activated only when the input current is at the balance point (the point at which the frequency of oscillation is precisely that indicated by the marker). At this point, the voltage on R420 goes from a maximum to a minimum and the voltage on R422 goes from a minimum to a

maximum. CR403 and CR404 form a diode adder. The most negative voltage applied to either diode will control the output. Hence, the output is first connected to R422 and then R420. Consequently, the amplifier has a waveform which is triangular in shape. The markers are positioned by potentiometers R932 (F_0), R927 (M_1), and R926 (M_2).

All three marker circuits operate in exactly the same manner. The marker signals, from the three marker circuits, are added together with a dc voltage, which controls their amplitude and the sum is applied to emitter follower Q419, and then to the amplitude modulation circuits.

3.12 LEVELING CIRCUITRY

The function of the leveling circuitry is to hold the power output of the backward wave oscillator constant over its operating frequency range. See Figure 3-9. It consists of three major components: the LEVELER-AMPLIFIER located on PC Board 600, the TRANSFER OSCILLATOR located in a shielded box on the left rear chassis of the instrument, and the GRID DRIVER AMPLIFIER located on PC Board 800.

The leveler-amplifier is a four stage differential amplifier consisting of transistors Q601 through Q608. The output of the amplifier is modulated by Q609. Transistors Q611 through Q615 are used to hold the frequency response of the leveler system relatively constant over the frequency range of the unit. This latter circuit is necessary to compensate for variations in grid sensitivity of the backward wave oscillator.

In the LEVELED mode, the rf power output of the backward wave oscillator is adjustable over at least a 6 db range by the POWER LEVEL control, R938, and is held constant by means of the feedback leveler circuit. The rf output is sampled by means of a directional coupler and is fed to an rf crystal detector. The crystal detector output voltage is applied to the input of the leveler-amplifier where it is compared to a dc reference

voltage. The voltage difference between the crystal output and the dc reference is amplified and applied to the grid of the backward wave oscillator. The action of the leveler system causes the crystal output voltage to match the dc reference voltage, thus making the backward wave oscillator power output a direct function of the dc reference voltage of the leveler. Thus, rf power output is determined by the magnitude of the leveler reference voltage which is set by the concentric POWER LEVEL control. Modulation is accomplished by modulating the reference voltage. To insure fast response modulation is also applied to the output of the leveler amplifier through Q609.

In the UNLEVELED mode, the power output is continuously adjustable from zero to maximum tube capability by the POWER LEVEL control. Rf sensing is inoperative and feedback is placed around the leveler-amplifier such that the output of the leveler-amplifier is a function only of the leveler reference voltage. The amplifier output and therefore the backward wave oscillator grid voltage are direct functions of the leveler reference voltage. When in this mode, all modulation is applied through Q609. The UNLEVELED mode of operation is normally used to obtain the maximum available rf power from the backward wave oscillator.

In the UNLEVELED PULSE mode, the POWER LEVEL control is bypassed and the leveler reference voltage is switched to a maximum. The AM INPUT jack is capacitively coupled as well as dc coupled to the grid of the backward wave oscillator, permitting external am modulation to be applied to the grid as well as to the leveler. Modulation rise and fall times are determined principally by the speed of the external source. In this mode, the output is fixed and is the maximum available from the tube.

The TRANSFER OSCILLATOR is used as a coupling system permitting the dc output voltage of the leveler-amplifier to be transferred to the elevated

grid potential of the backward wave oscillator. The rf output of the amplitude modulated oscillator passes through high voltage capacitors and is detected at the cathode potential of the backward wave oscillator. The dc output of the transfer oscillator detector is amplified by the GRID DRIVER AMPLIFIER and applied between the cathode and grid of the backward wave oscillator. Thus, any dc or modulation signals applied to the input of the transfer oscillator are reproduced on the grid of the backward wave oscillator. This allows all modulation and a greater part of the leveling circuitry to be operated near ground potential.

Transistor Q751 serves as the transfer oscillator while modulation of Q751 is by transistor Q750. The high voltage capacitors which couple the rf output of the transfer oscillator to the detector are C757 and C759. Diodes CR750 and CR751 detect the rf output of the oscillator while Q752 serves as a buffer amplifier. The output of Q752 is filtered and applied to the input of the grid driver amplifier. Q808 and Q809 serve as the grid driver amplifier, the grid of the BWO being connected to the collector of Q808.

3.13 MODULATION CIRCUITRY

The modulation circuitry, located on PC Board 500, is shown schematically on Figure 3-10. Modulation is accomplished by either an externally applied signal or an internally generated square wave. Square wave voltage is produced by an astable multivibrator consisting of transistors Q501 and Q502 and a bistable multivibrator circuit, Q503 and Q504. The bistable multivibrator insures square wave symmetry and fast rise and fall time. The square wave frequency can be varied by a front panel control (R937) over a frequency range of 800 to 1200 cps. External modulation is applied to the unit at the AM INPUT jack and is dc coupled to the modulation circuitry. When the MODULATION control is in the AM EXTERNAL position and no signal present at the AM INPUT jack, the backward wave oscillator is cut off. A +15 volt

signal, applied to the AM INPUT jack, will turn the tube on to the level determined by the POWER LEVEL control. For fast pulse modulation, the external signal must drive the backward wave oscillator grid from cutoff to zero volts. The voltage required varies from tube to tube but in no case exceeds 75 volts. Other modulation inputs applied to the leveler, through the modulation circuitry, are the markers and blanking modulation. Markers are applied to the leveler

reference voltage during leveled operation and to the leveler output through Q309 during unleveled operation. Rf power output can be obtained during sweep retrace by disabling the internal blanking modulation. This is done by placing the RETRACE control to the ON position. Internal SQUARE WAVE, external AM and RF OFF modulation is applied to the leveler through Q505. Marker modulation is applied to the leveler through Q506.



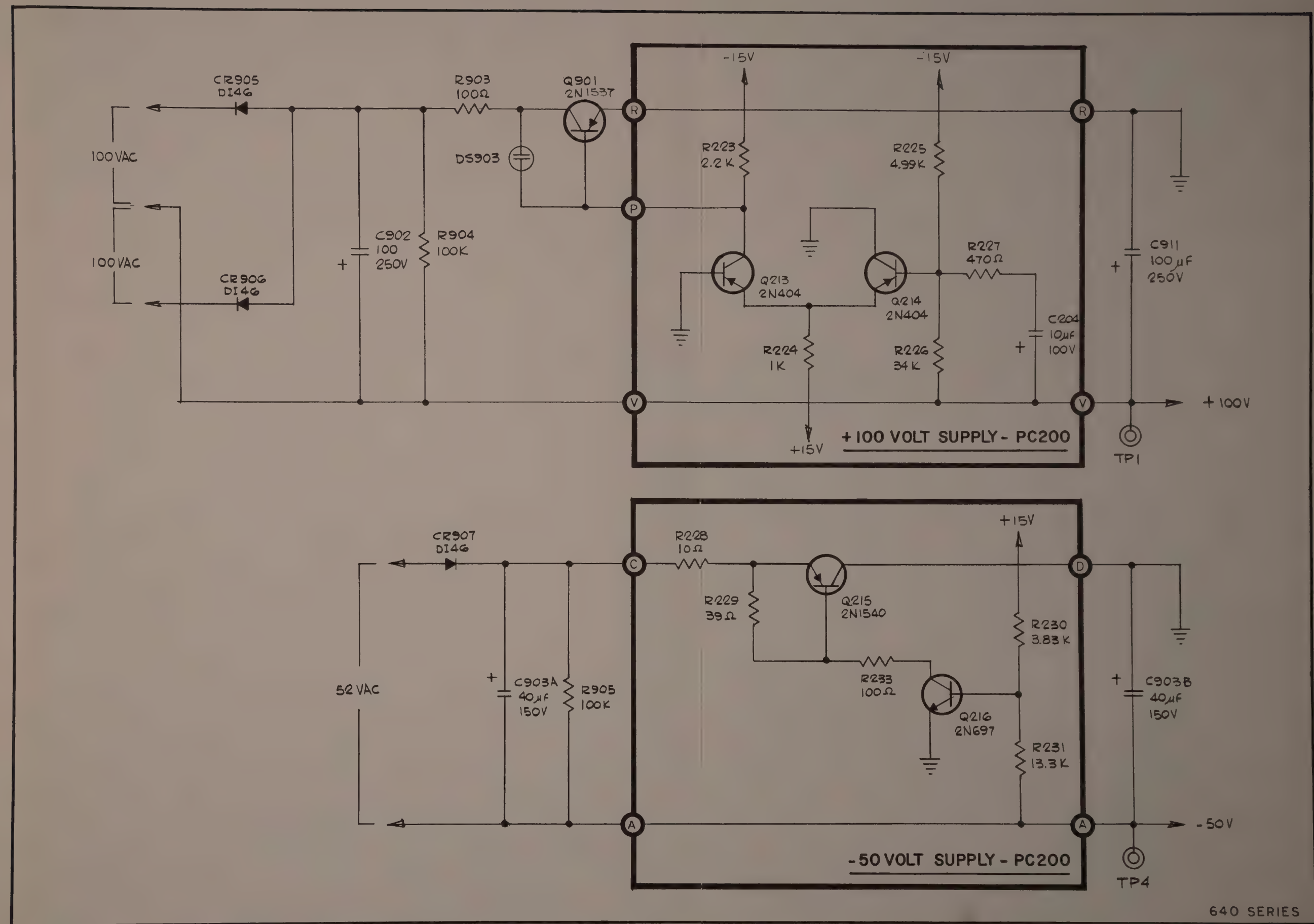
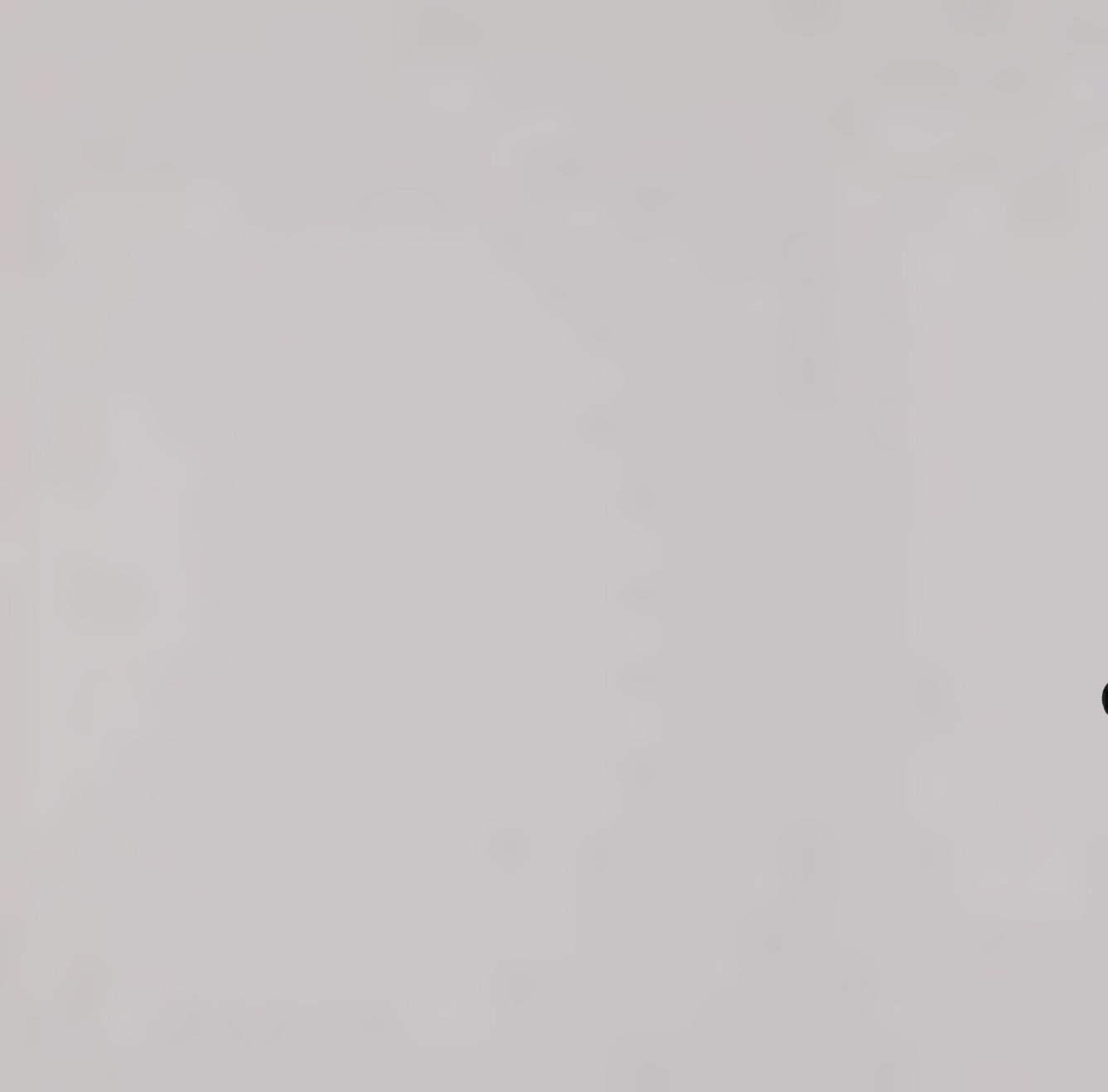


FIGURE 3 - 4



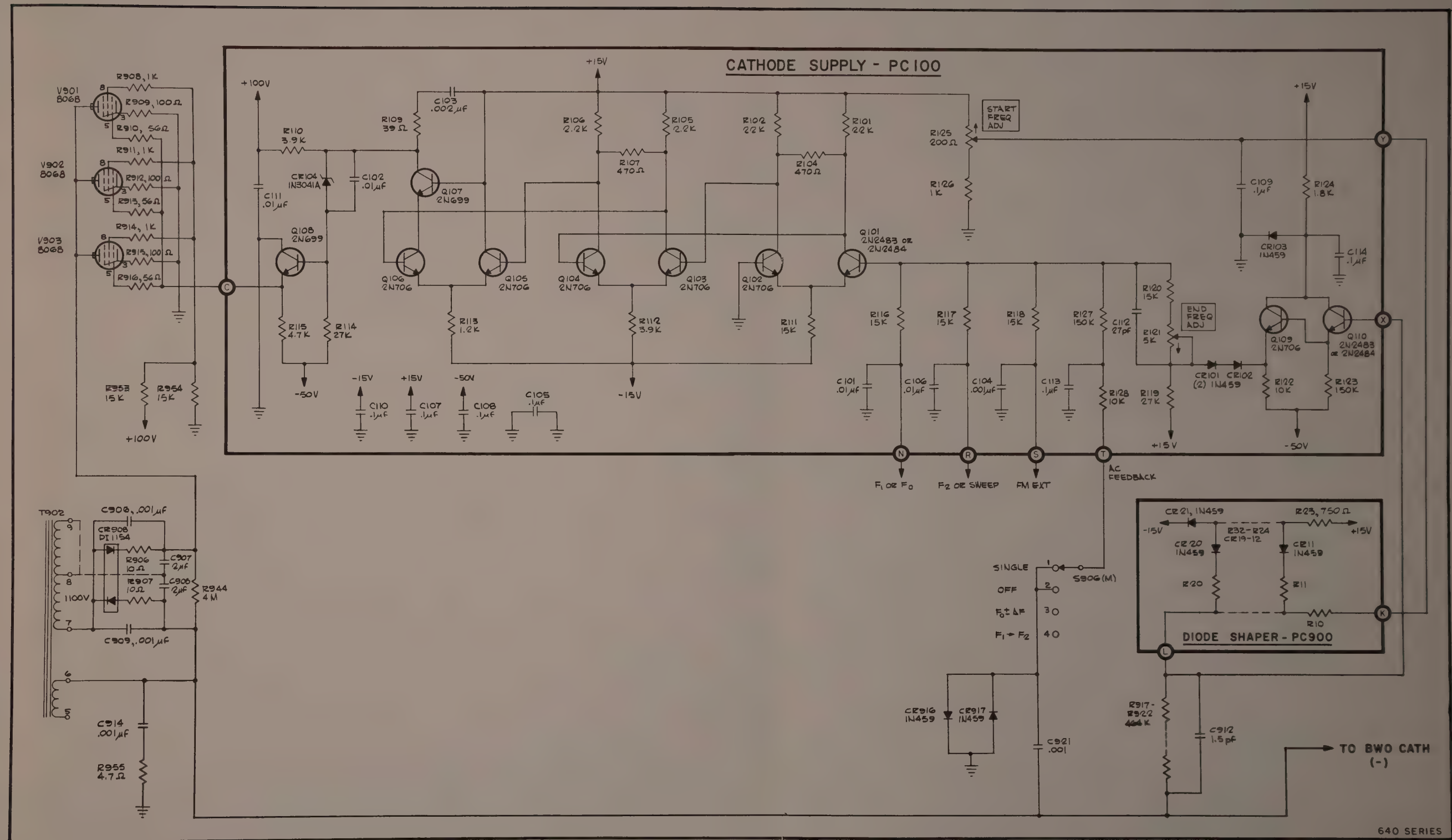


FIGURE 3-5

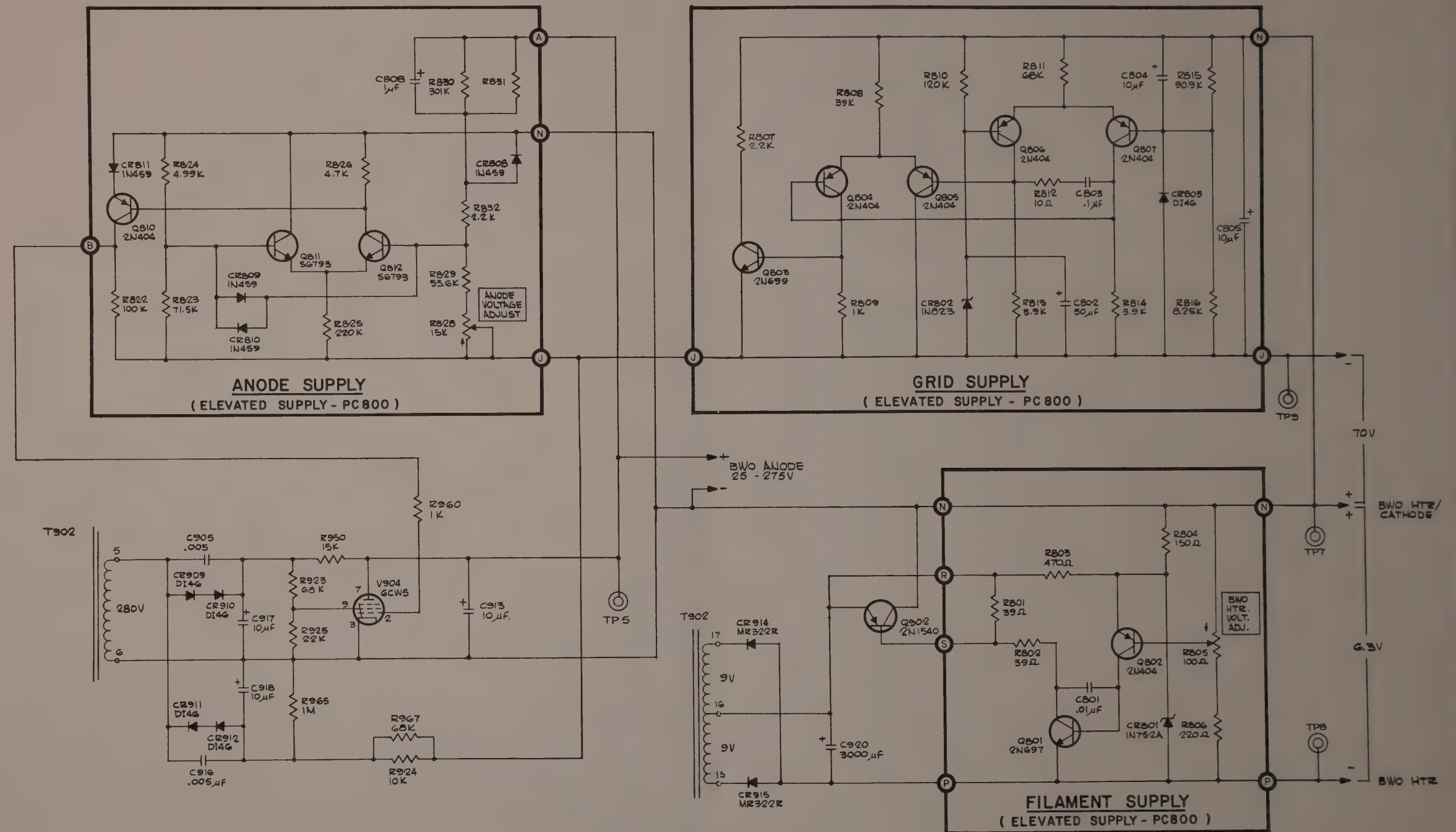


FIGURE 3 - 6

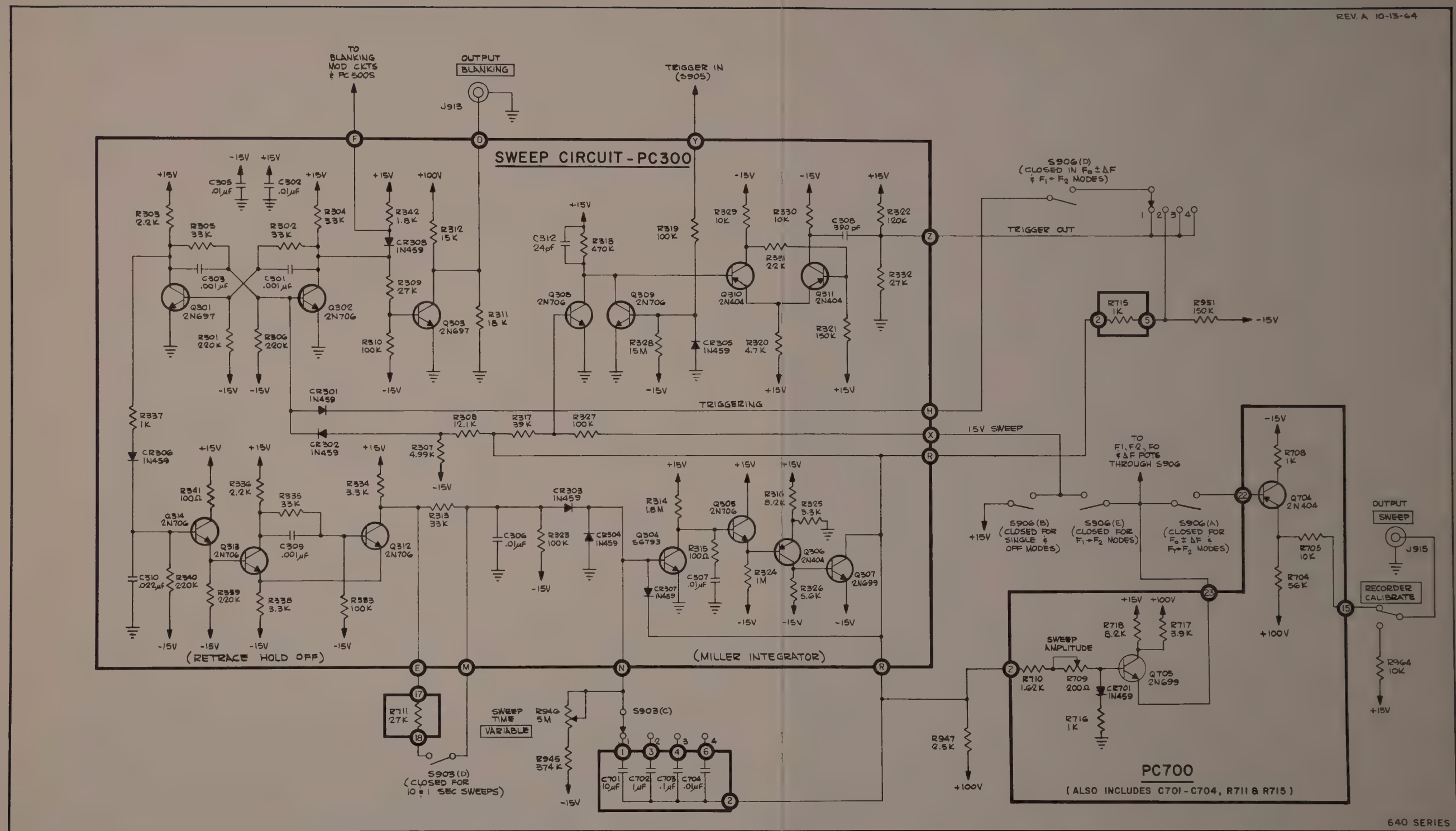


FIGURE 3-7

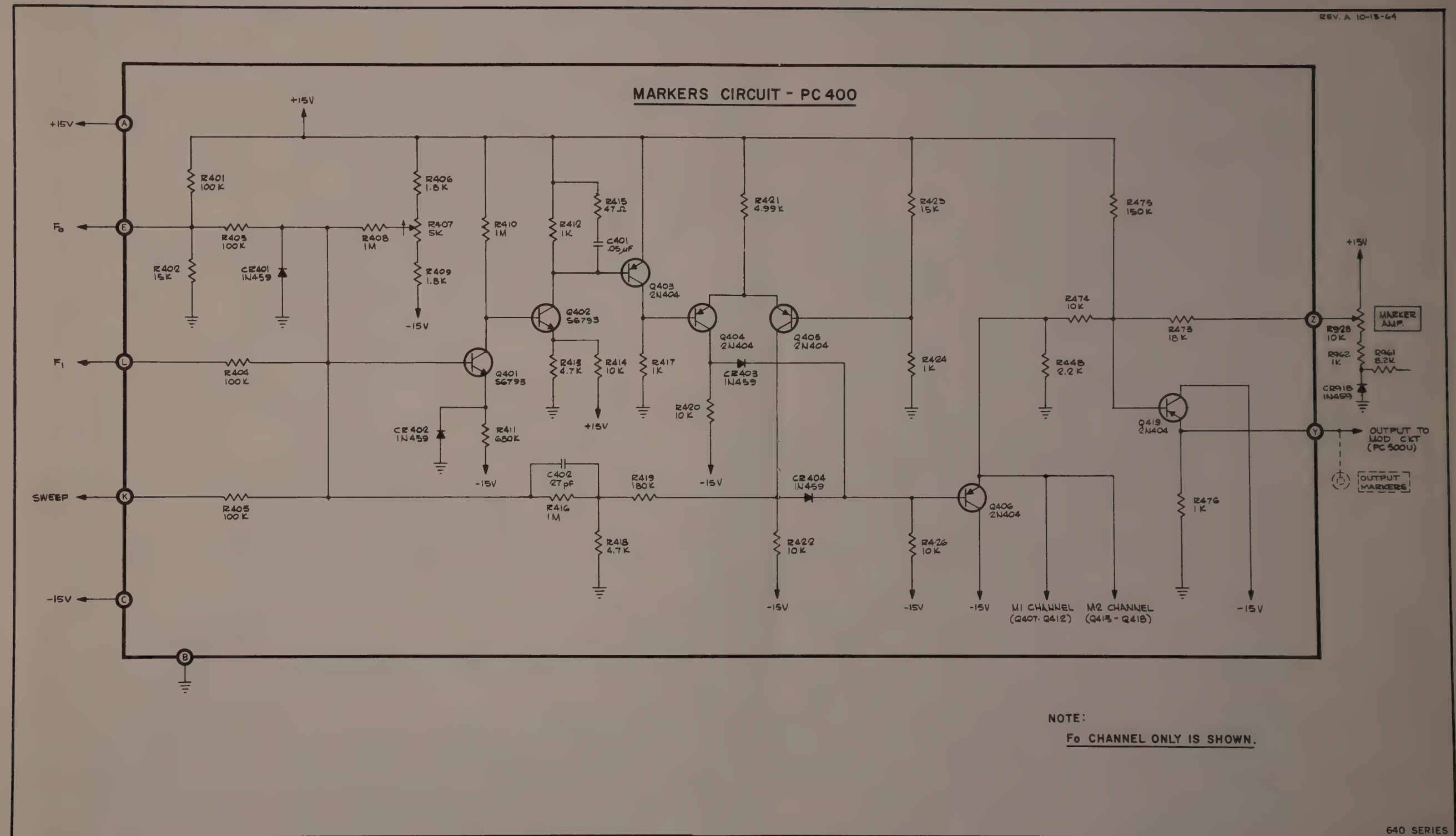


FIGURE 3-8

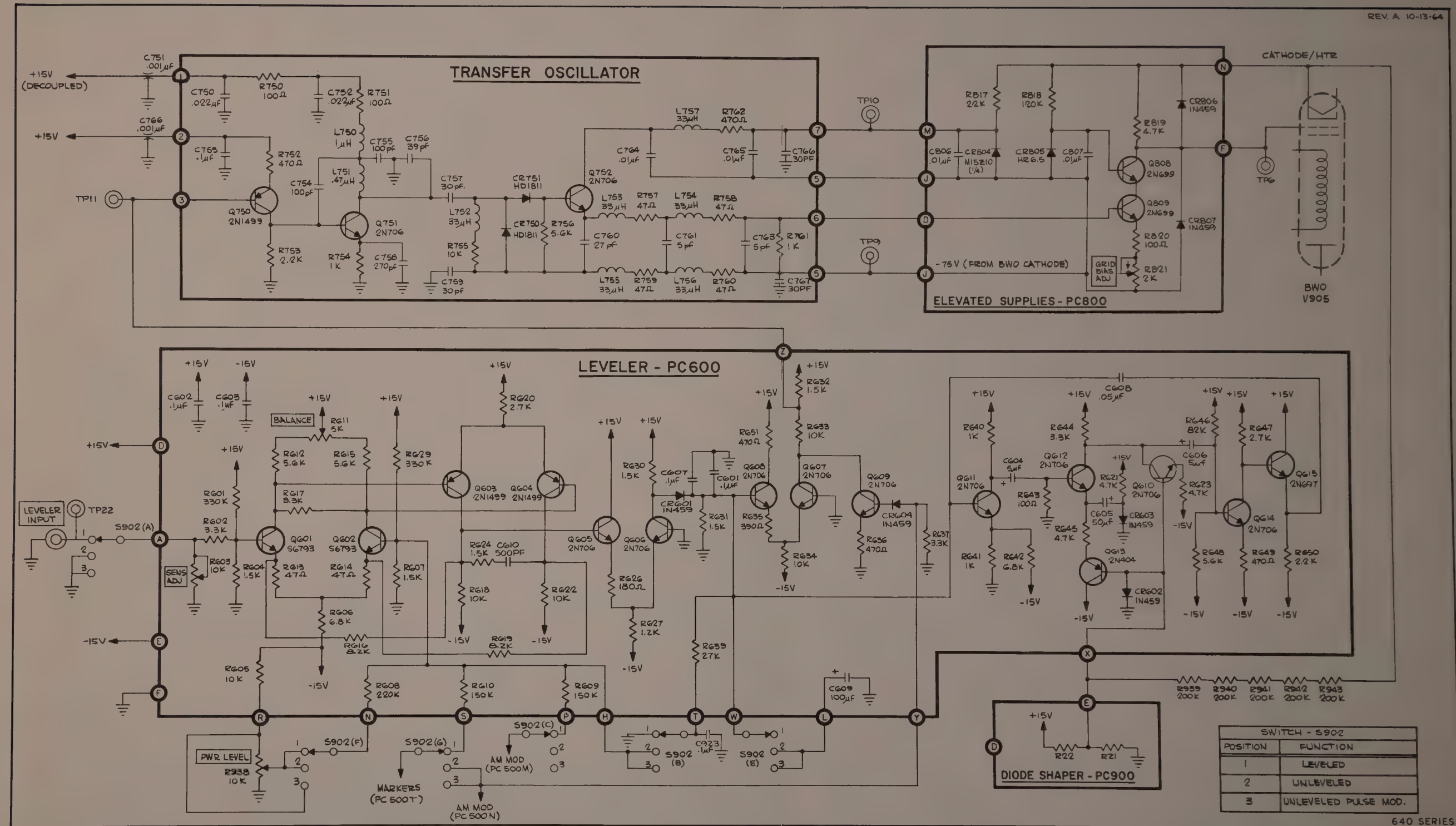


FIGURE 3-9

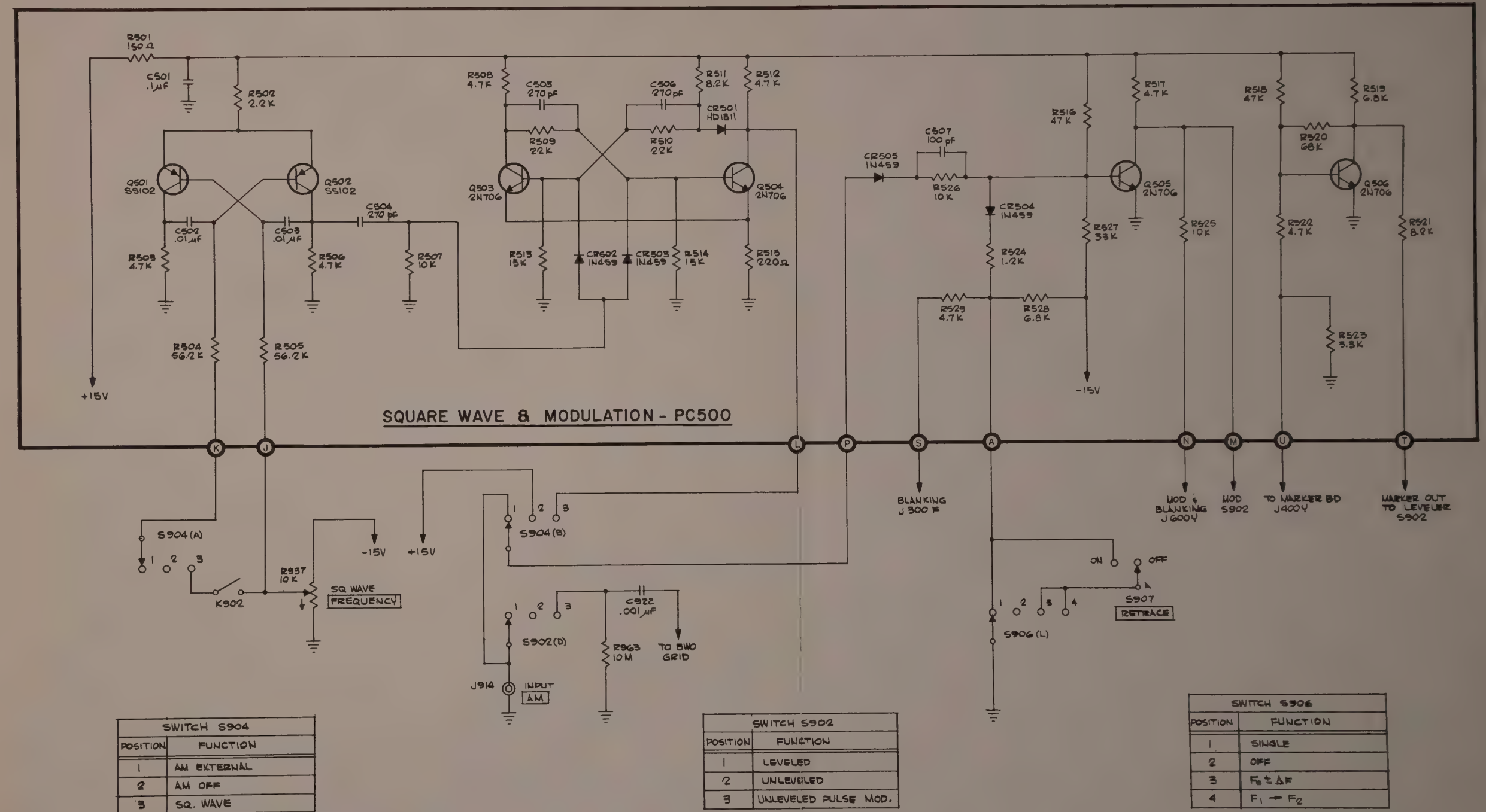
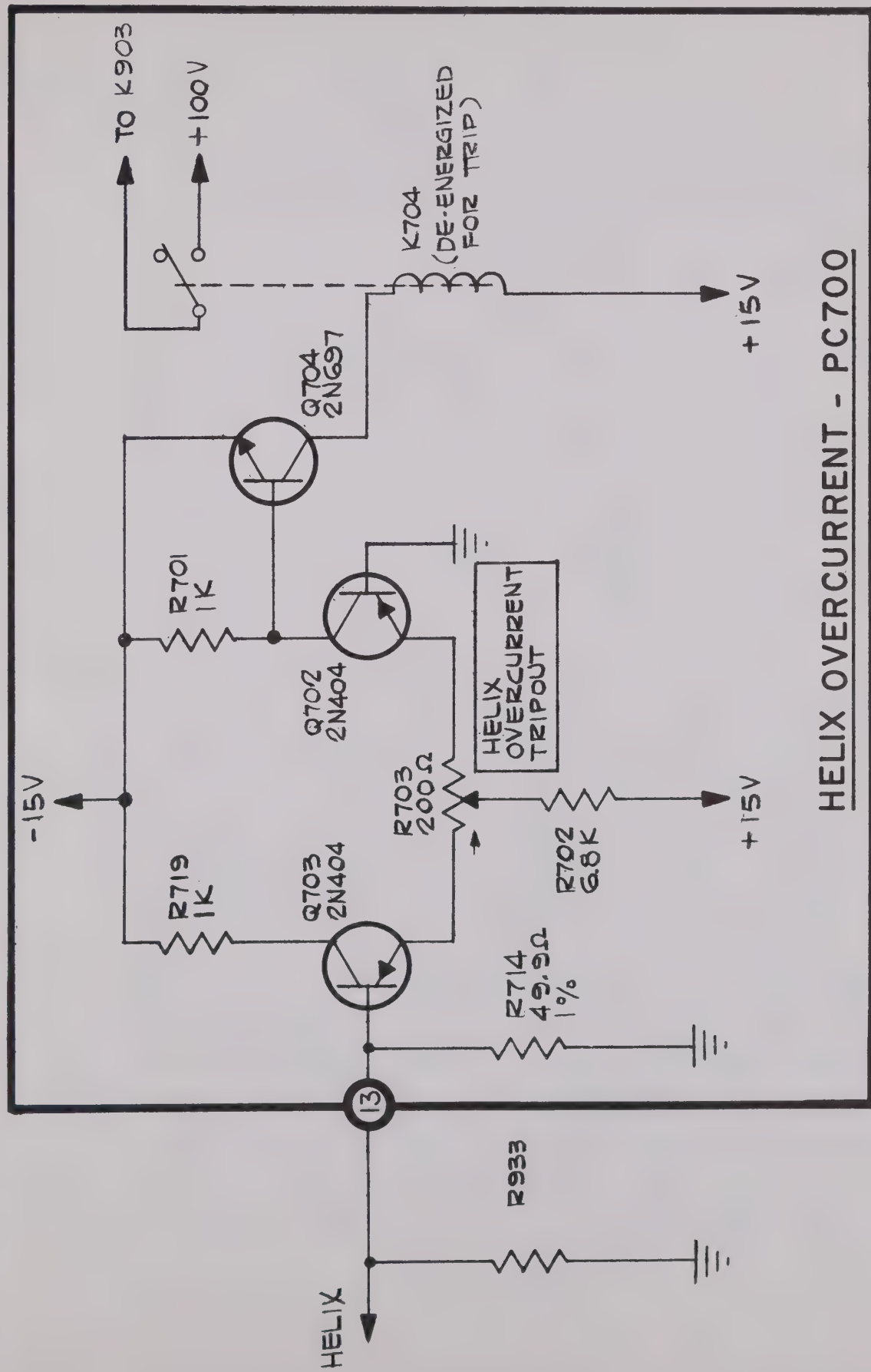


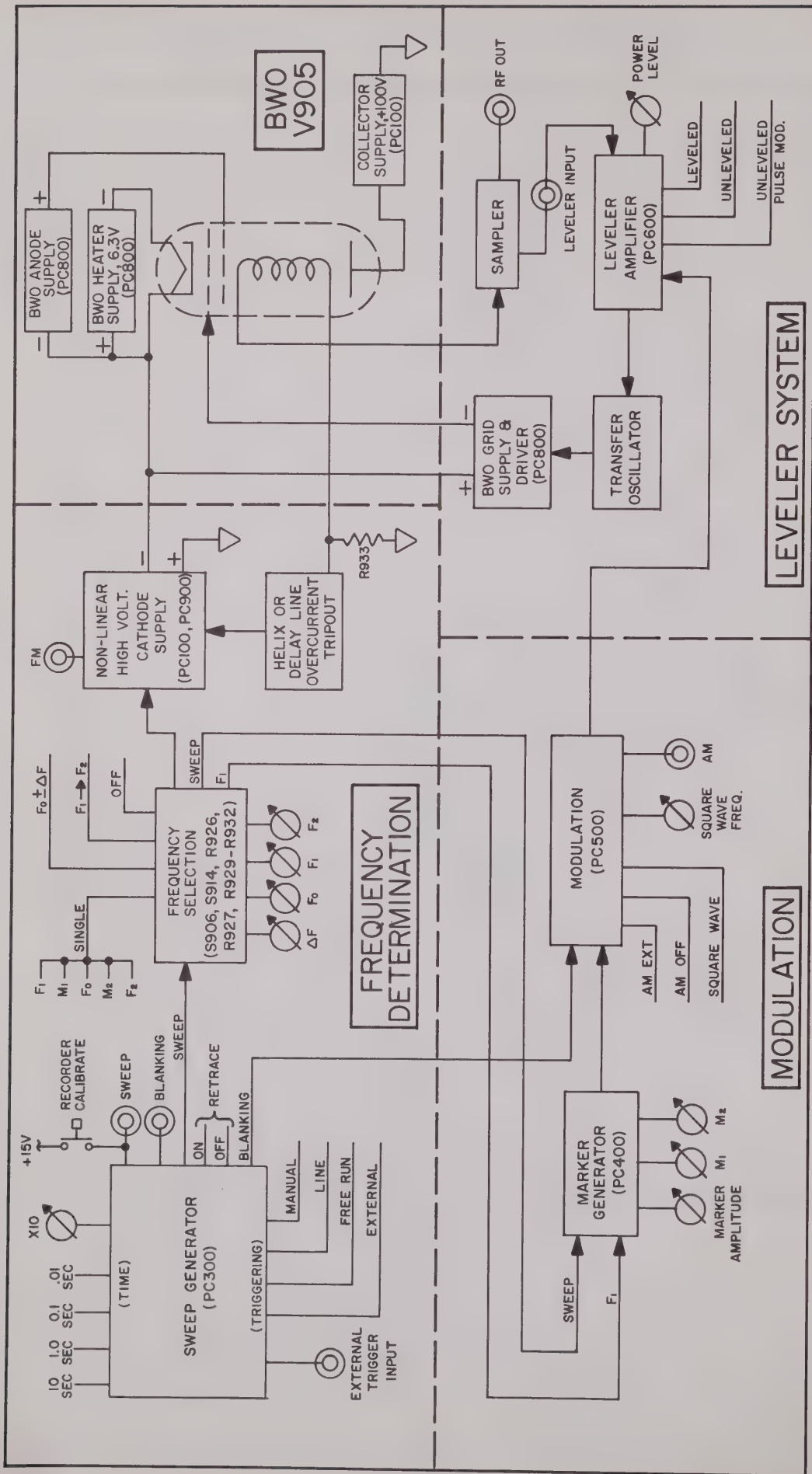
FIGURE 3-10



HELIX OVERCURRENT - PC700

640 SERIES

FIGURE 3-11



MODEL 640 SWEEP OSCILLATOR
BLOCK DIAGRAM
FIGURE 3-12

SECTION 4 - MAINTENANCE

CAUTION: High voltages exist in this instrument. Observe caution when calibrating or performing maintenance on the instrument. When the back or top cover plates are removed, the high voltage interlock turns the HIGH VOLTAGE OFF.

4.1 TROUBLE SHOOTING

NOTE: Before attempting to trouble shoot the instrument, be certain that an apparent trouble is actually due to a malfunction within the instrument and not to improper control settings or external causes.

4.1.1 GENERAL

1. Check all fuses. Replace with type 3AB, 250 volt and current value specified.
2. If power can be applied without blowing fuse, check the four low voltage power supplies; +15, -15, +100 and -50 and the elevated supplies; the anode, grid and filament.

NOTE: A floating voltmeter must be used to check the elevated supplies.

3. If a power supply is at fault, the cause may be due to a defective transistor or tube or one of the circuits using the supply may be excessively loading it due to a defective or grounded component.

4.1.2 NO HIGH VOLTAGE WITH HIGH VOLTAGE INDICATOR LIGHT OFF

1. Check to see if K901 - 9, 8 to -3, 4 closes after 60 seconds.
2. Check the thermal time delay relay. Check for 6.3 volts at XK901, -1, -6.
3. Check K902. If it does not close, check the

+100 volt supply.

4. See if the jumper at TB901 -1, -2 is in place.
5. Check to see if K903 is de-energized. If not, check the HELIX TRIP-OUT circuit, as follows:
 - a. Set the RF OUTPUT control to UN-LEVELED.
 - b. Set rear switch, S913, to HELIX/DELAY LINE.
 - c. Set FREQUENCY mode selector to SINGLE; F_0 .
 - d. Connect a suitable voltmeter to TP18 and TP19 located in rear of instrument.
 - e. Turn POWER switch to ON.

After approximately 60 seconds the high voltage should momentarily appear. Note the meter reading while the high voltage is present. If it is equal to or slightly greater than the value given in CHART #1, Section 5, the backward wave oscillator tube should be checked. If the relay trips out at a meter reading which is appreciably lower than the value indicated, then the setting of the TRIP-OUT circuit should be checked according to the procedures of the OVERCURRENT TRIP-OUT ADJUSTMENT, Paragraph 4.4.2.

4.1.3 NO HIGH VOLTAGE WITH HIGH VOLTAGE INDICATOR LIGHT ON

1. Check the output of T902. **CAUTION: HIGH VOLTAGE,** 1100 volts rms at terminals 7 and 9.
2. Check the rectifier (CR908) and the filter circuit.
3. Check series tubes V901, V902 and V903.

4. Trouble shoot the cathode supply board, J900.

4.1.4 NO RF UNDER ANY CONDITION

1. With the HIGH VOLTAGE OFF, check the backward wave oscillator heater voltage between +TP7 and -TP8. Value should be approximately 6.3 volts. If not, try to adjust to 6.3 volts by using R804 (see Figure 4-4).

If value cannot be obtained, trouble shoot the filament supply on PC Board 800.

2. With the POWER OFF, disconnect P920 from J920. Measure the resistance at pins C and B of P920. The value should be approximately 6 ohms. If the circuit shows open, the filament of the backward wave oscillator tube is open and the tube should be replaced. If the filament is not open, reconnect P920 and J920.
3. With the POWER and HIGH VOLTAGE ON, the MODULATION control at AM OFF; the FREQUENCY mode selector at SINGLE; F_0 , the RF OUTPUT control at UNLEVELED and the F_0 FREQUENCY control at 0 on the logging scale, measure the cathode voltage between (+) TP0 and (-) TP7. Compare with the tube data sheet in the envelope in back of the manual. Move F_0 FREQUENCY control to 100 on the logging scale. Again check with sheet. If values do not check out, trouble shoot high voltage supply.
4. With the HIGH VOLTAGE ON, measure the anode voltage between (+) TP5 and (-) TP7. (CAUTION: HIGH VOLTAGE.) The value should be approximately the value indicated on the tube data sheet located in the envelope. If not, try to adjust to correct value by using the ANODE ADJUST R828. (See Figure 4-4.)

CAUTION: Do not advance the ANODE ADJUST beyond the point where collector or helix current is greater than the value speci-

fied by the tube manufacturer. See envelope in back of manual.

5. Measure the voltage between (-) TP2 and (+) TP11. The value should be approximately 1/4 volt. If not, trouble shoot the modulation circuit (PC 500) and the switching in the modulation circuit (located on the rear of the front panel).
6. Measure the voltage between (-) TP9 and (+) TP10 (CAUTION: HIGH VOLTAGE). The value should be approximately 15 volts. Measure the voltage between (+) TP7 and (-) TP9. The value should be approximately 70 volts. If these voltages do not check out, trouble shoot the GRID supply.

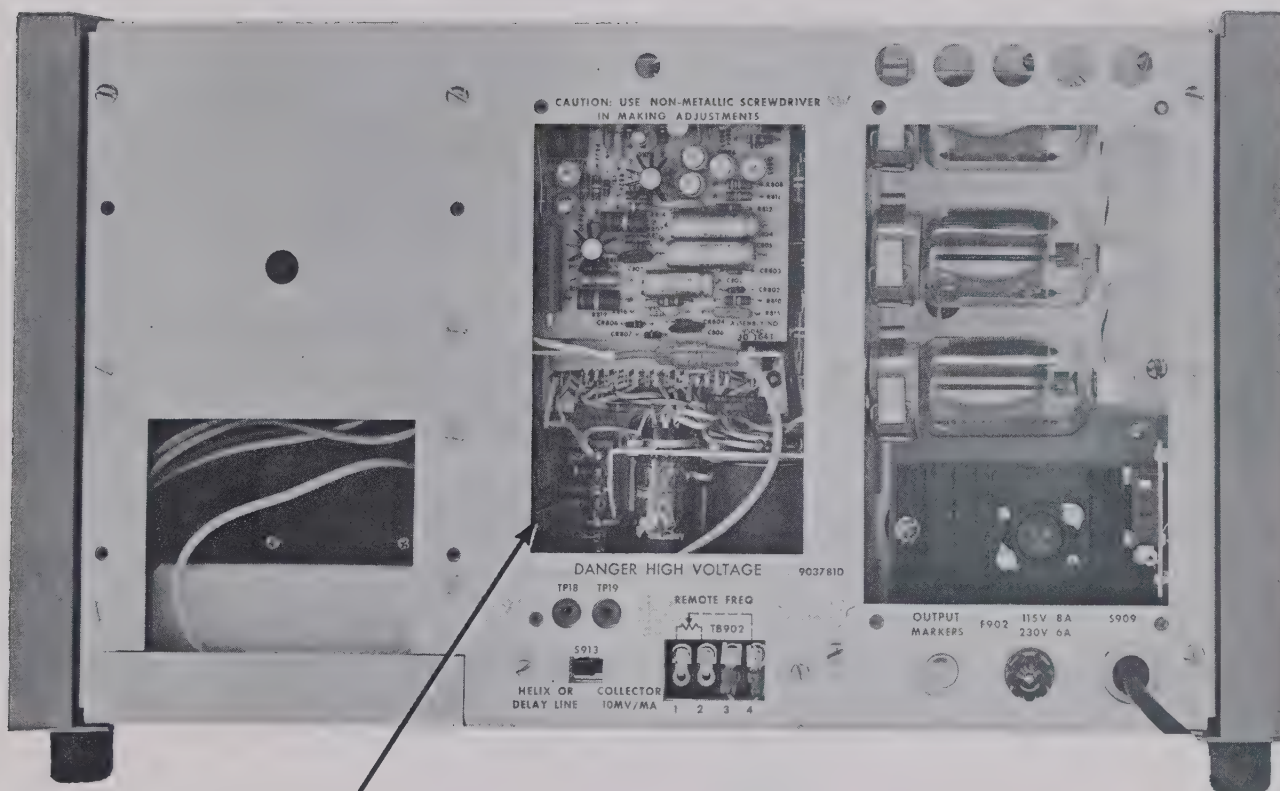
With the RF OUTPUT control at UNLEVELED, the FREQUENCY mode selector at SINGLE; F_0 and the MODULATION control at AM OFF, measure the grid voltage between (+) TP7 and (-) TP6. The value should be less than two volts. If not, check the grid driver stage and the transfer oscillator on PC Board 800 (Elevated Supply).

7. If all power supplies and voltages check out and there is no indication of helix or collector current on the meter, replace the backward wave oscillator tube, V905.

4.1.5 RF NOT LEVELED OR NO RF OUTPUT WHEN RF OUTPUT CONTROL IS IN LEVELED POSITION

NOTE: When the RF OUTPUT control is in the LEVELED position and the power of the unit varies less than the specified value for your instrument (see Specifications, Page 1-1) as indicated on a suitable power meter over the full frequency range, the rf is LEVELED. If the power varies more than the specified value, perform the following:

1. Set FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$.



J920 & P920 - CONNECTOR (6 PIN)

REAR VIEW
FIGURE 4-1

2. SWEEP TIME to .01 seconds, calibrated.
3. SWEEP TRIGGER to LINE.
4. RETRACE control to OFF.
5. POWER LEVEL control full clockwise.

Connect the horizontal input of a suitable oscilloscope to the SWEEP OUTPUT jack of the unit. Adjust the horizontal input to give a full trace on the scope. Connect the vertical input to TP22, located on the back of the front panel. Adjust backward wave oscillator grid voltage per Paragraph 4.4.4.

Set RF OUTPUT control to UNLEVELED. Check to see if there is output across the entire frequency range.

Switch RF OUTPUT control to LEVELED. The output should decrease from UNLEVELED level across the entire frequency range and the output should be approximately 75 to 100 millivolts. If not, try to make the following adjustment: Turn BALANCE potentiometer (R611) (see Figure 4-3), full counterclockwise. Then adjust XTAL SENS potentiometer (R603) for approximately 100 millivolts at the minimum power point in frequency range (this point is usually at the low end). Adjust R611 until output over entire frequency range is approximately 100 millivolts. If this can be done, the unit will be leveled. If not, trouble shoot the leveler amplifier, grid driver and transfer oscillator circuitry.

The transfer oscillator and grid driver can be spot checked by performing the following:

FREQUENCY mode selector to SINGLE; F_0 .

RF OUTPUT control to UNLEVELED.

POWER LEVEL control full clockwise.

Connect a voltmeter to (+) TP7 and (-) TP6.

The voltage should be approximately 0 volts.

Switch FREQUENCY mode selector to OFF.

The voltage should now be approximately the value of the GRID VOLTAGE CUTOFF given on Addendum Sheet 'A' in envelope in rear of manual.

4.1.6 UNIT UNABLE TO SWEEP

1. Set FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$.
2. Set SWEEP; TIME control to .01 seconds, calibrated.
3. Set SWEEP; TRIGGER control to FREE RUN.
4. Check diodes and transistors on PC Board 300.
5. Check the waveforms and compare to those of Figure 4-2.

4.2 TEST POINTS

See Figures 4-3 and 4-4.

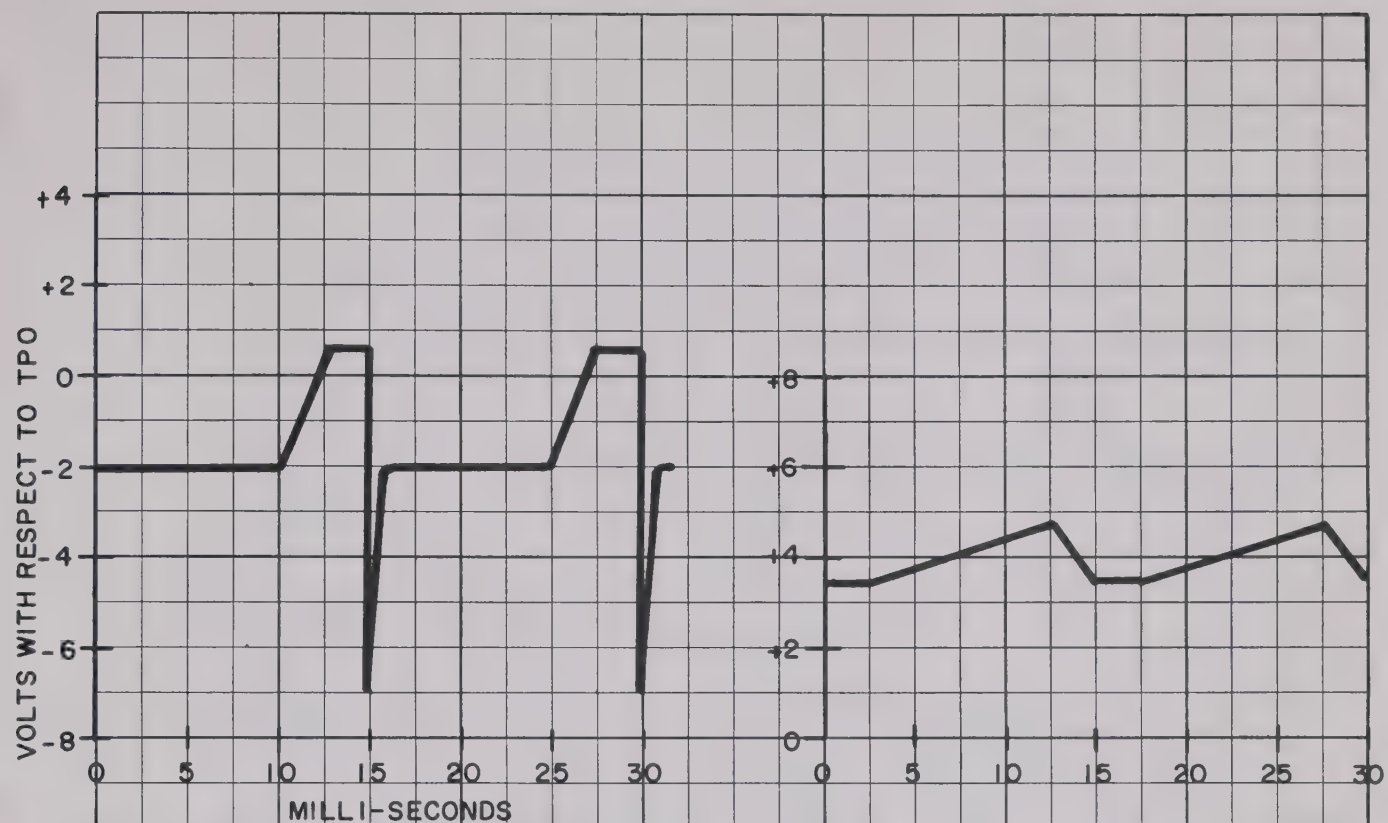
NOTE: TP0 through TP4 located left side of instrument. TP5 through TP10 located top rear insulated board.

TP0 chassis ground.

TP0 to TP1, +100 volts (low voltage supply; 97 volts to 103 volts).

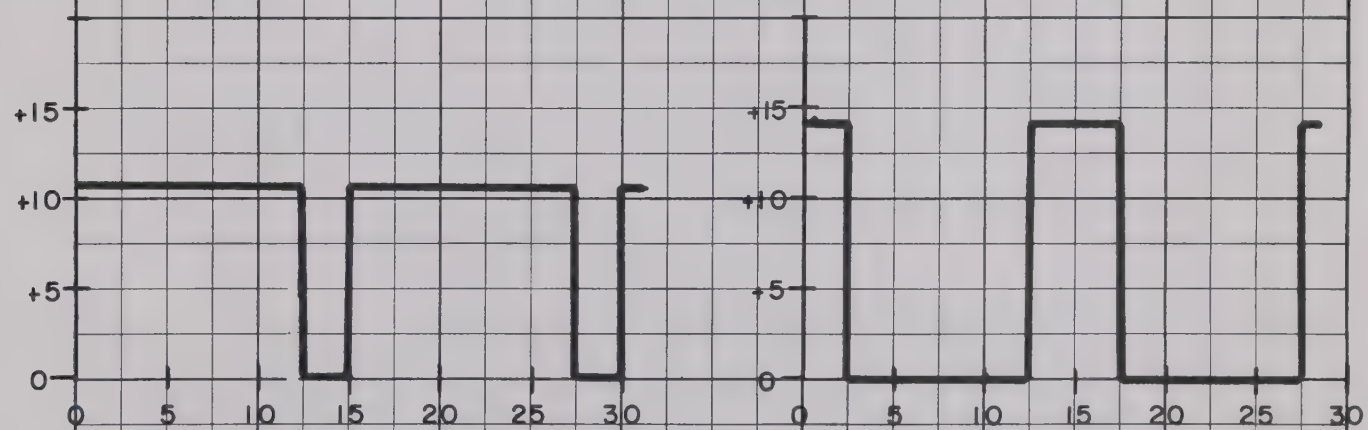
TP0 to TP2, +15 volts (low voltage supply; +15 volts).

TP0 to TP3, -15 volts (low voltage supply; 14.9 volts to 15.1 volts).



BASE Q302

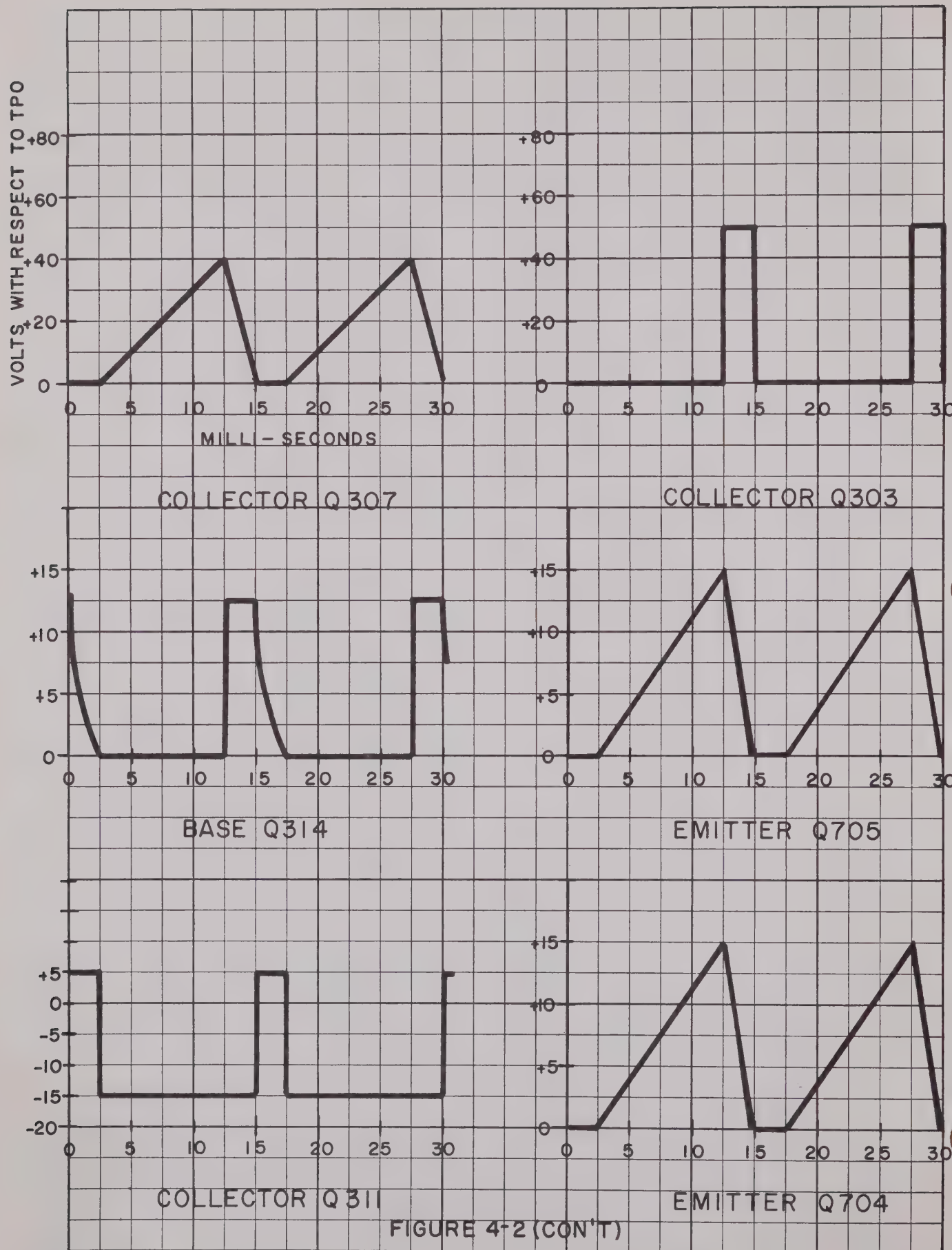
COLLECTOR Q304



COLLECTOR Q302

COLLECTOR Q312

SWEEP CIRCUIT WAVEFORMS
FIGURE 4-2



TP0 to TP4, -50 volts (low voltage supply; 45 volts to 55 volts).

TP7 to TP5, backward wave oscillator anode voltage (see envelope - Addendum A - for value).

TP7 to TP6, backward wave oscillator grid. (See envelope - Addendum A - for value.)

TP7 to TP9, backward wave oscillator grid supply (-70 volts to -75 volts).

TP0 to TP7, backward wave oscillator cathode.

TP7 to TP8, backward wave oscillator heater (6.2 volts to 6.4 volts).

TP10 to TP9, supply for transfer oscillator (approximately 15 volts).

TP2 to TP11, input to transfer oscillator (approximately 1/4 volt). TP11 located on main chassis near C903.

TP22, output of sampler (TP22 located on back of front panel).

4.3 CALIBRATION

4.3.1 FREQUENCY CALIBRATION

1. Turn POWER switch to ON with an appropriate rf wavemeter, crystal detector and oscilloscope connected to the RF OUTPUT of the unit.
2. Set RF OUTPUT control to LEVELED.
3. Set FREQUENCY mode selector to SWEEP; $F_0 \pm \Delta F$.
4. Set F_0 FREQUENCY indicator to the lowest frequency value of the instrument (0 on the logging scale).

5. Set the rf wavemeter to this frequency.
6. Adjust R125 (START FREQUENCY ADJUST) so the wavemeter pip appears in the center of the oscilloscope face. See Figure 4-3.

NOTE: ΔF AMPLITUDE control should be full on (clockwise).

7. Reduce the ΔF AMPLITUDE control while adjusting R125 so the pip remains in the center.
8. Move F_0 FREQUENCY indicator to the high frequency value of the instrument (100 on logging scale).
9. Set the rf wavemeter to this frequency.
10. Adjust R121 (END FREQUENCY ADJUST) so the wavemeter pip appears in the center of scope face.

NOTE: ΔF AMPLITUDE control should be full on (clockwise).

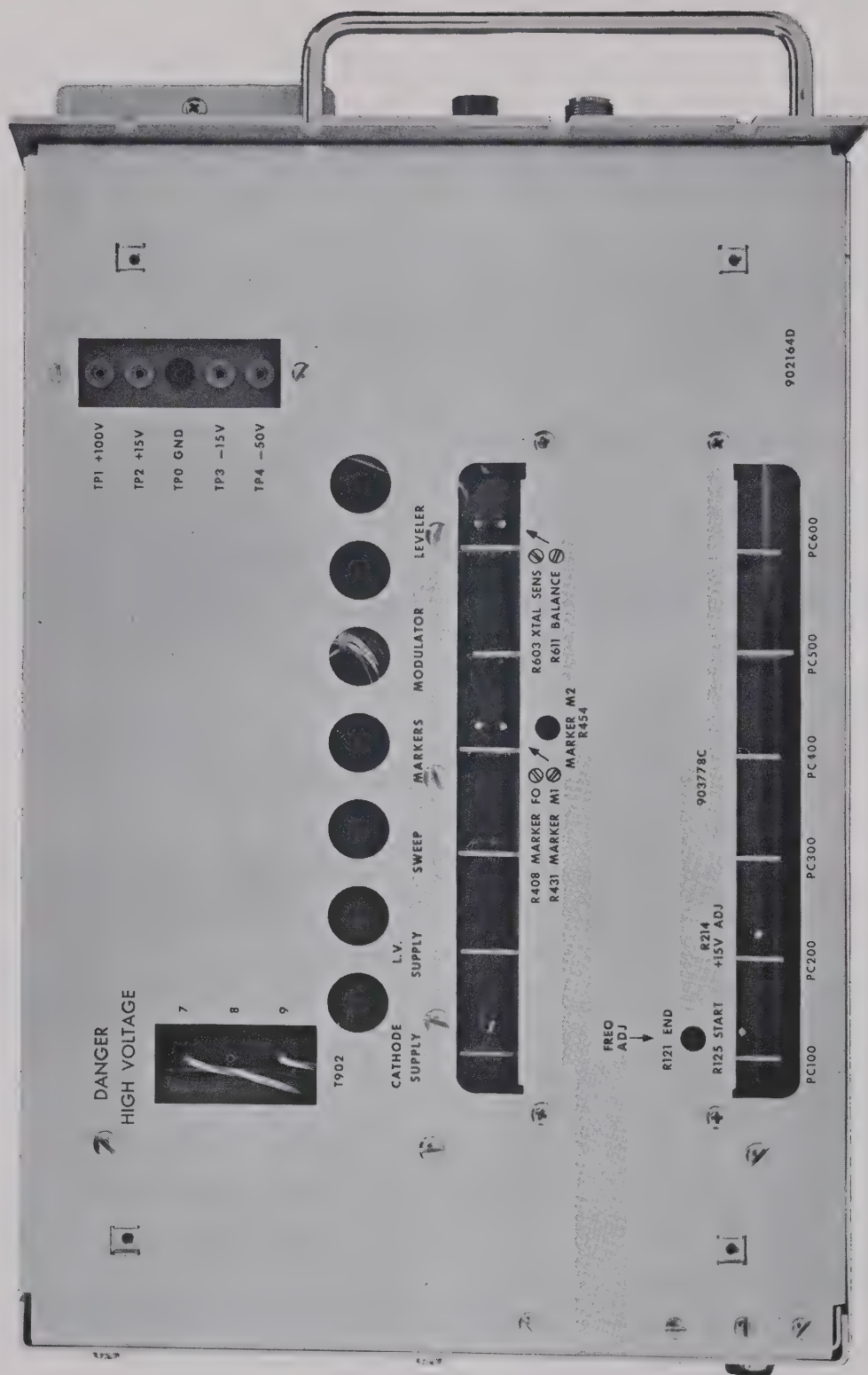
11. Reduce the ΔF AMPLITUDE control while adjusting R121 so the pip remains in the center of the oscilloscope face.

Repeat Steps 1 through 11 until both ends are on frequency. Repeating the steps is necessary because of the interaction of R125 and R121.

4.3.2 WIDE SWEEP CALIBRATION

See Figure 4-4.

1. FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$.
2. F_1 FREQUENCY control to 0 on logging scale.
3. F_2 FREQUENCY control to 100 on logging scale.
4. Adjust frequency meter to frequency of F_2 setting.



LEFT SIDE VIEW

FIGURE 4-3

4. Adjust R709 until pip is exactly at end of sweep as seen on the oscilloscope.

4.3.3 MARKER CALIBRATION

1. Set RF OUTPUT control to LEVELED.
2. Set FREQUENCY mode selector to SWEEP;
 $F_1 \rightarrow F_2$.
3. Set F_1 FREQUENCY control to 0 on the logging scale.
4. Set F_2 FREQUENCY control to 10 on the logging scale.
5. Set SWEEP; TIME to .1 second (calibrated).
6. Set SWEEP; TRIGGER to LINE.
7. Turn MARKER AMPLITUDE up as necessary.
8. Apply the sweep output of the unit to the horizontal deflection input of an oscilloscope.
9. With a suitable frequency meter and crystal detector in series with the output, display the output of the crystal detector on the oscilloscope.
10. Set the M_1 MARKER control to any frequency between 0 and 10 on the logging scale.
11. Set the frequency meter to this frequency.
12. Adjust R432 (MARKER M_1) until the wavemeter pip and the marker pip coincide.
13. Remove M_1 marker pip from the oscilloscope and set the M_2 MARKER control to the frequency of the frequency meter.
14. Adjust R455 (MARKER M_2) until the wavemeter pip and the marker pip coincide.

15. Remove M_2 marker pip from the oscilloscope and set F_0 FREQUENCY control to the frequency of the frequency meter.

16. Adjust R407 (MARKER F_0) until the two pips coincide.

4.4 INTERNAL ADJUSTMENTS

NOTE: Both the top and rear cover plates actuate safety interlock switches that prevent high voltage operation when removed.

4.4.1 +15 VOLT ADJUSTMENT

See Figure 4-3.

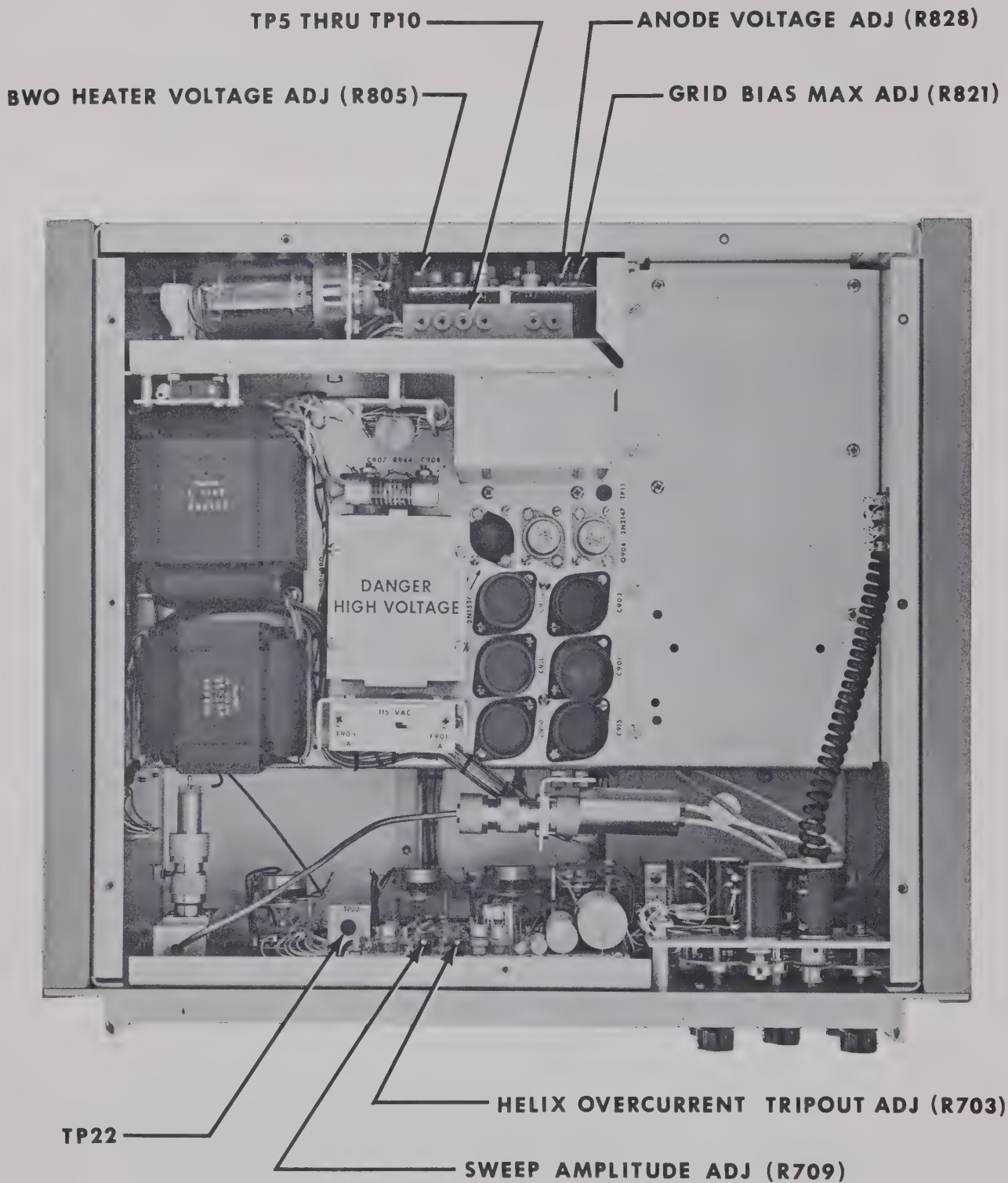
1. Remove the left handle side cover plate.
2. Connect a 0.1% dc voltmeter between TP2 and TP0.
3. Adjust R214 (+15 VOLT ADJUST) for 15.00 volts.
4. This adjustment also affects the -15 volt, +100 and -50 volt supplies, but the absolute value of these supplies is not critical.
5. Replace the left handle side cover plate.

4.4.2 OVERCURRENT RELAY TRIP-OUT ADJUSTMENT

See Figure 4-4.

Check Chart #1, Section 5, for proper setting and full scale reading of CURRENT TRIP-OUT value when switch S913 is in HELIX/DELAY LINE setting.

1. Remove the top cover.
2. Connect a 3 K ohm resistor, a 20 K or greater potentiometer and a suitable current meter



TOP VIEW
FIGURE 4-4

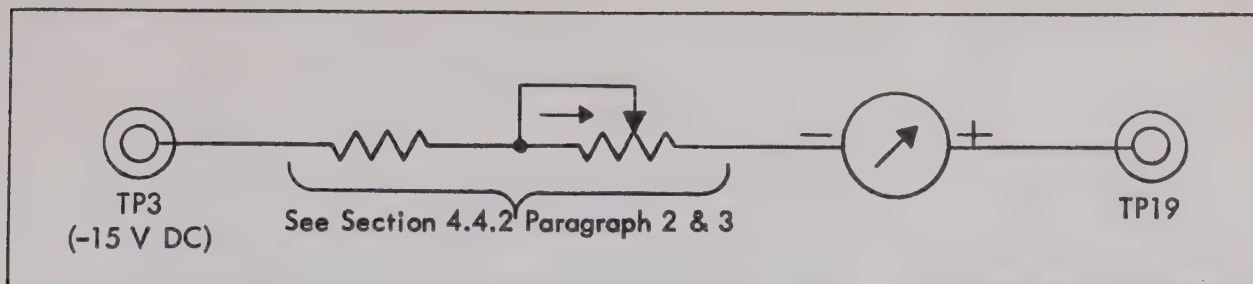


Figure 4-5

(5 ma) between TP3 (-15 v dc) and TP19. This set up is for a full scale deflection of 5 ma.

3. For a full scale deflection of 50 ma, connect a 270 ohm resistor, a 5 K ohm or greater potentiometer and a suitable current meter (50 ma) between TP3 (-15 v dc) and TP19.

See Figure 4-5.

4. Turn POWER switch to ON but leave the HIGH VOLTAGE off by leaving the high voltage interlock open.
5. Set rear switch, S913, to HELIX/DELAY LINE.
6. Adjust the potentiometer by starting at a low value of current and gradually increase until the overcurrent relay, K701, trips (de-energizes). Check current at which relay tripped. Adjust R703 so the relay trips at the current value indicated in Chart #1.

NOTE: Always proceed from a low current value by adjusting the potentiometer each time the trip-out point is checked.

4.4.3 BACKWARD WAVE OSCILLATOR HEATER ADJUSTMENT

See Figure 4-4.

1. Remove the top cover plate.
2. Turn POWER switch to ON but leave the HIGH VOLTAGE off by leaving the high voltage interlock open.
3. Set FREQUENCY mode selector to OFF.
4. Set F_0 FREQUENCY indicator to 0 on logging scale.
5. Set MODULATION control to AM OFF.

6. Set SWEEP; TRIGGER to FREE RUN.

7. Set SWEEP; TIME to .01 seconds.

8. Connect the positive lead of a dc voltmeter to TP7 and the negative lead to TP8.

9. With the instrument ON and the backward wave oscillator connected, adjust R805 to 6.3 volts dc. (This should be done at 115 volt line.)

10. Replace top cover plate.

4.4.4 BACKWARD WAVE OSCILLATOR GRID ADJUSTMENT

See Figure 4-4.

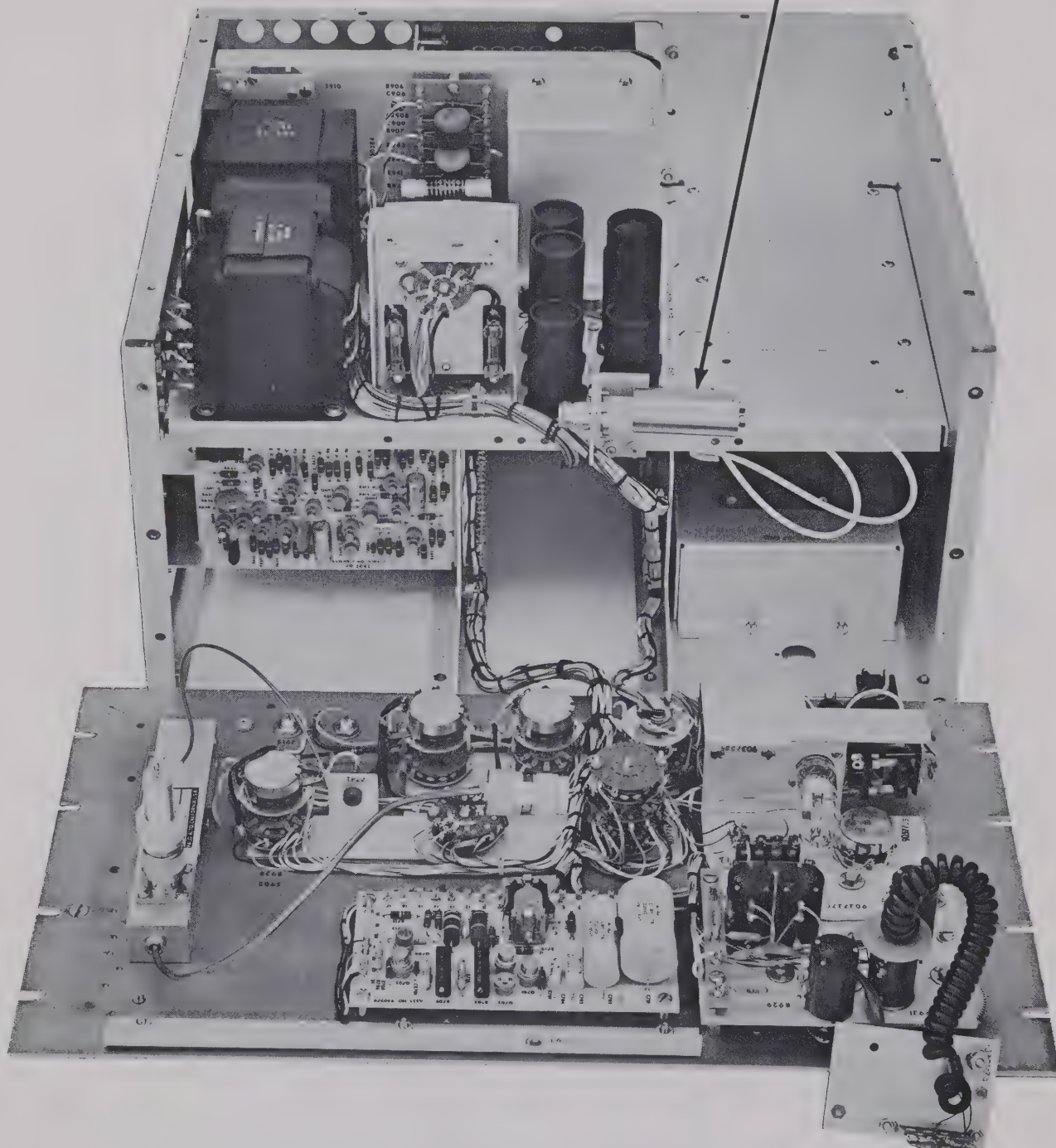
Remove the rear cover plate. Turn POWER switch to ON.

1. RF OUTPUT control to UNLEVELED.
2. FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$.
3. MODULATION control to SQUARE WAVE.
4. RETRACE control to OFF.
5. Adjust the GRID BIAS MAX. ADJUST (R821) so that the backward wave oscillator tube does not generate any rf during retrace and during the portion of the square wave where rf is off.

4.5 FRONT PANEL

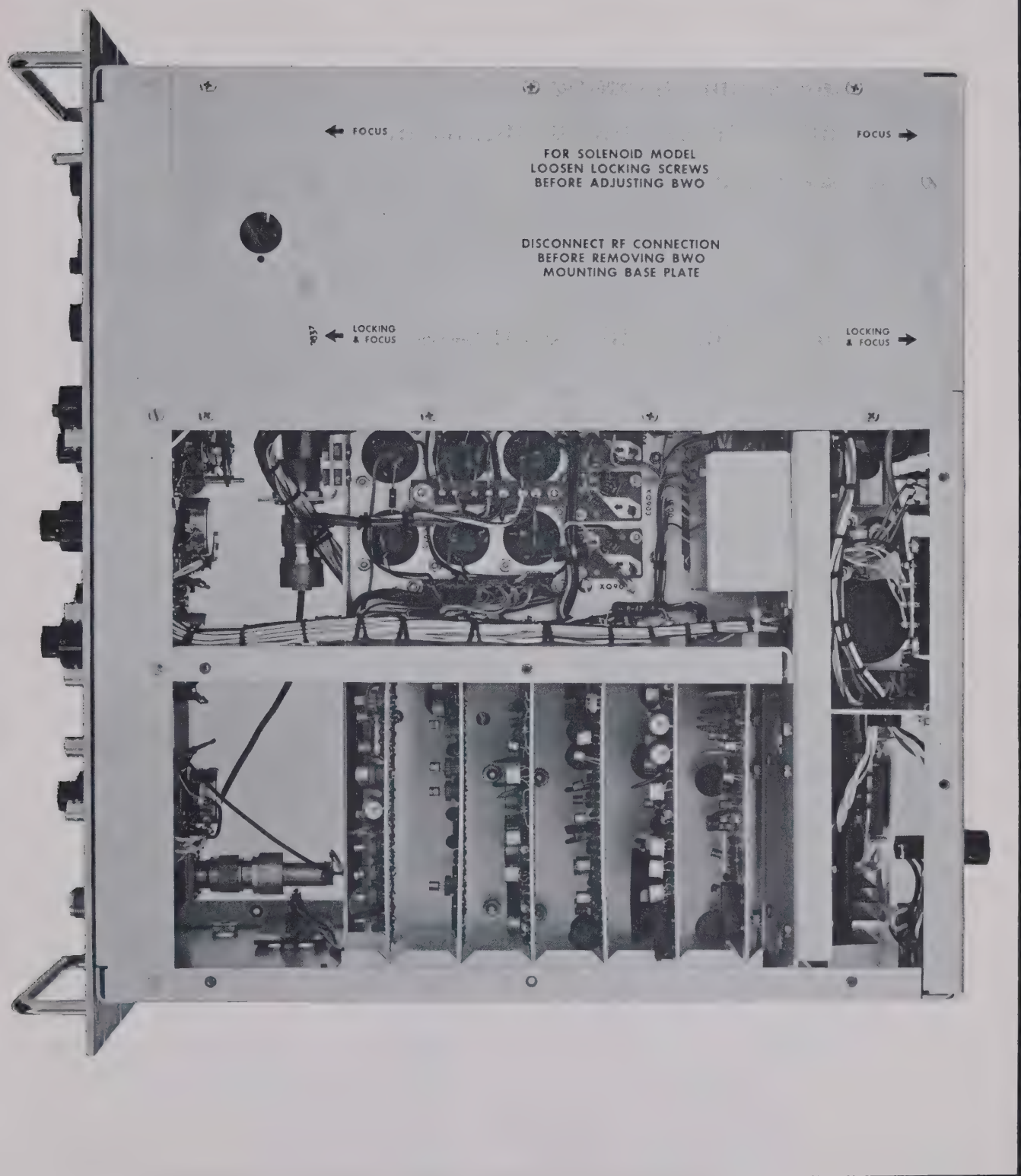
The front panel may be dropped forward for access to components mounted inside. Remove the five control knobs and the dial mechanism cover. Remove the top cover plate and the right and left handle sides. Remove the coiled cable bracket (two screws). Remove any rf connections using caution. Remove the screws from the periphery of the front panel. The panel may now be turned

BALUN



FRONT VIEW (PANEL OPENED)

FIGURE 4-6



forward on its face as all wiring comes out the bottom of the panel.

4.6 BACKWARD WAVE OSCILLATOR TUBE REPLACEMENT

See Figure 4-7.

To replace the backward wave oscillator tube, remove the top cover plate.

1. Disconnect the rf connection from the tube to the unit.

NOTE: On units with baluns, disconnect the balun bracket from the unit before disconnecting the rf connector. Remove the balun from its bracket prior to Step 2. See Figure 4-6.

2. Turn unit over and remove the bottom cover plate.
3. Disconnect the one and six pin connector (P921 and P920).

NOTE: Some units have only the six pin connector (P920).

4. Remove the seven Phillips head screws from the periphery of the backward wave oscillator mounting base plate. See Figure 4-7.
5. Lift the whole tube assembly (tube and base plate) from the unit by using the finger hole provided.
6. Disconnect the tube from its base plates. Note position and screw hole alignment of old tube to aid in positioning of new tube.
7. Reverse procedure for installation.

4.7 FREQUENCY AND MARKER POTENTIOMETER REPLACEMENT

NOTE: The F_1 and F_2 potentiometers can be removed without dropping the front panel.

A. REPLACEMENT OF F_1 POTENTIOMETER

1. Remove top cover.
2. Unsolder leads from potentiometer terminals.
3. Rotate F_1 control knob full counterclockwise (CCW) to its lower mechanical stop. It is important to remember the exact position of the indicator when the stop is reached, as this position must be maintained when the new potentiometer is installed.
4. Loosen both potentiometer shaft gear hub set screws.

CAUTION: Do not disrupt relative position of the F_2 potentiometer shaft gears. Make a pencil mark on the mounting plate and gear and realign before meshing the F_1 gear. If the F_2 gears are moved and not realigned, the mechanical stops will not be oriented and realignment must be performed according to the procedures of Section B, starting with Step 8.

5. Slide gear forward.
6. Remove potentiometer retaining nut and washer. While holding nut, washer and gear, withdraw potentiometer from mounting plate, noting orientation of potentiometer terminals.
7. Insert new potentiometer engaging washer, nut and gear. Tighten retaining nut, remembering orientation of potentiometer terminals.
8. Position the F_1 potentiometer shaft full clockwise (CW) as viewed from the shaft end. This can best be accomplished by lightly tightening one gear set screw and while the gear is disengaged, finger turning the shaft full clockwise. Loosen the set screw.

9. Before engaging the gear, check to see if the dial indicator is in the exact position as it was before and check to see if the F_2 gear lines up with its pencil mark.
10. Engage the F_1 potentiometer shaft gear and tighten both screws. NOTE: If the indicator is not in the exact position as noted in Step 3, do not position it by turning the F_1 dial cord drum. Instead, disengage the gear and reposition the indicator.

B. REPLACEMENT OF F_2 POTENTIOMETER

1. Remove the top cover, the five control knobs, and the dial mechanism cover.
2. Unsolder the three leads from the potentiometer terminals. Remove the three small screws which hold the coiled wire bracket to the back of the potentiometer. The coiled wire is now free.
3. Rotate F_1 knob full counterclockwise (CCW) and the F_2 knob full clockwise (CW).
4. Loosen F_2 potentiometer gear hub set screws on both gear hubs.
5. Remove F_2 potentiometer by turning the potentiometer case in a clockwise direction as viewed from the shaft end.
6. Insert new potentiometer and tighten by turning in a counterclockwise direction.
7. Tighten set screws on gear hub closest to the mounting plate.
8. Disengage the idler gear connecting the F_1 potentiometer shaft gear to the F_2 potentiometer body gear.
9. Set the upper mechanical stop. This stop can be seen as a bent tooth on the gear on the F_2

potentiometer shaft and a small extension on the F_2 dial indicator shaft gear. The stop must be set below the center line of the F_2 dial indicator gear and the F_2 potentiometer gear as the F_2 knob turns clockwise.

It may take a few attempts but no difficulty should be encountered.

10. Tighten the potentiometer shaft gear set screws.
11. Rotate the F_2 knob counterclockwise until the F_2 indicator is approximately $1/64$ " from the F_1 indicator. Now, while holding the F_2 knob so as to maintain the $1/64$ " distance, rotate the entire F_2 potentiometer counterclockwise (CCW) until the mechanical stop is felt. If the indicators touch because the F_2 knob was allowed to turn after the stop was reached, a slight clockwise turn on the F_2 knob will separate them.
12. Very carefully engage the idler gear between the F_1 potentiometer shaft gear and the F_2 potentiometer body gear (the one closest to the mounting plate) and tighten set screws.

The lower and upper mechanical stops are now set. A gap should be maintained between indicators over the entire distance of the dial. Adjustments should be made beginning with Step 8 if gap is not maintained.

13. After the stops have been set, run the F_2 indicator full clockwise (CW) and the F_1 indicator to approximately 50 on the logging scale.
14. Remove the three screws from the back of the F_2 potentiometer.

CAUTION: Do not let the back of the potentiometer come off.

15. Secure the coiled wire bracket to the back of the potentiometer, and solder the three leads to the potentiometer terminals.

C. REPLACEMENT OF M_2 POTENTIOMETER

NOTE: Removal of the M_1 , M_2 or F_0 potentiometer requires dropping the front panel forward.

Remove the top cover, the right and left handle sides, the five control knobs and the dial mechanism cover. Remove the screws from the periphery of the front panel. Remove the screws which hold the coiled cable to the side of the instrument. Remove any applicable rf connections. Drop front panel forward.

1. Unsolder the wires to potentiometer terminals.
2. Turn the M_1 and M_2 knobs full counterclockwise (CCW).
3. Remove retaining ring and thrust washer from the M_2 knob shaft.
4. Loosen the two set screws on the M_2 knob shaft gear hub.
5. Loosen the M_2 dial cord hub and press M_2 knob shaft about halfway out.
6. Loosen potentiometer shaft gear hub set screws.
7. Remove potentiometer retaining nut and washer and remove M_2 potentiometer remembering orientation of potentiometer terminals.
8. Position idler gear (with planetary gear) and new potentiometer shaft full clockwise (CW) as viewed from the front panel.
9. Insert new potentiometer and tighten retaining nut remembering potentiometer orientation.
10. Engage potentiometer shaft gear and tighten set

screws. Make sure the potentiometer shaft is full clockwise (CW).

11. Press M_2 knob shaft into place and replace thrust washer and retaining ring.
12. Engage M_2 knob shaft gear with idler gear and potentiometer shaft gear.
13. Tighten set screws on M_2 knob shaft gear.
14. Rotate M_2 knob fully counterclockwise (CCW).
15. Rotate M_2 dial cord CCW until dial indicators are approximately 1/64" apart.
16. Tighten M_2 dial cord drum set screw.

D. REPLACEMENT OF THE M_1 POTENTIOMETER

1. Remove the Helix Overcurrent PC Board assembly. This will permit a wrench to be inserted from the left side of the gear assembly as viewed from the front of the unit.
2. Position M_1 and M_2 control knobs full CCW. Note position of indicators.
3. Loosen the M_1 potentiometer shaft gear hub set screws.
4. Remove M_1 potentiometer retaining nut and withdraw M_1 potentiometer, remembering orientation of potentiometer terminals.
5. Insert new potentiometer. Tighten retaining nut.
6. Replace M_1 potentiometer shaft gear making sure that the M_1 indicator is in previous position and the M_1 potentiometer shaft is full clockwise (CW).
7. Tighten set screws on potentiometer shaft gear.

8. Replace Helix Overcurrent PC Board.

9. Resolder leads.

E. REPLACEMENT OF THE F_0 POTENTIOMETER

1. Rotate the F_1 , F_0 and F_2 control knobs full counterclockwise (CCW).

2. Unsolder the leads to the F_0 potentiometer terminals.

3. Remove the F_1 knob shaft retaining ring and thrust washer.

4. Loosen the F_1 dial cord drum set screws, remembering the exact position of F_1 indicator.

5. Move F_1 knob shaft forward disengaging F_1 knob shaft gear. Loosen F_1 knob shaft gear hub set screws.

6. Slide F_1 knob shaft forward until inner locking ring bottoms on F_1 knob shaft gear.

7. Loosen set screws on F_0 potentiometer shaft gear.

8. Loosen potentiometer retaining nut.

9. Withdraw potentiometer remembering orientation of potentiometer terminals.

10. Insert new potentiometer positioning shaft full clockwise (CW) as viewed from the shaft end.

11. Tighten potentiometer retaining nut.

12. Engage F_0 potentiometer shaft gear and tighten two set screws.

13. Loosen set screw on F_0 dial cord drum and note position of indicator. Rotate F_0 knob full counterclockwise (CCW). The stop of the potentiometer should be felt.

14. Position the F_0 indicator to position as noted in Step 13.

15. Tighten F_0 dial cord drum set screw.

16. Replace F_1 knob shaft into position and replace thrust washer and retaining ring.

17. With the F_1 potentiometer shaft fully clockwise (CW), slide the F_1 knob shaft gear up and intermesh with F_1 potentiometer shaft gear. Tighten gear set screws.

18. Rotate F_1 knob shaft fully counterclockwise (CCW) and tighten F_1 dial cord drum after positioning indicator as it was before, Step 4 above.

19. Resolder leads.

4.8 WARRANTY

All workmanship and materials except the backward wave oscillator tube are guaranteed for one year. Details covering warranty adjustments are presented on "Shipment Damage Claim" at the end of this manual.

SECTION 5
CHARTS and GRAPHS

CHART #1
Information for Individual 640 Models

MODEL NUMBER	T902	R933	S913 HELIX/DELAY LINE (FULL SCALE)	J900 HELIX- SHAPER BOARD	V905 BWO	CA1 COUPLER	DETECTOR	SAMPLER	CURRENT TRIP-OUT VALUE	E ₁	E ₂	E ₃	RF CIRCUIT DIAGRAM
641B	7 & 8	12.5 Ω	5 ma	950373	SE214C				5 ma				5-1
641KB	7 & 8	12.5 Ω	5 ma	950373	SE214C	950421 (17 db)	950541	950535	5 ma				5-1
641B-S1	7 & 8	12.5 Ω	5 ma	950384	SE219				5 ma				5-1
641KB-S1	7 & 8	12.5 Ω	5 ma	950384	SE219	950425 (17 db)	950541	950537	5 ma				5-1
642B	7 & 9	12.5 Ω	5 ma	950319	SE215A-2				3.5 ma				5-1
642KB	7 & 9	12.5 Ω	5 ma	950319	SE215A-2	950411 (13 db)	950541	950536	3.5 ma				5-1
643B	7 & 9	12.5 Ω	5 ma	950323	SE211A-8				3.5 ma				5-1
643KB	7 & 9	12.5 Ω	5 ma	950323	SE211A-8	Narda 3044-10 (10 db)	950541	950542	3.5 ma	LP Filter 256-3		RF Cable 950356B-1	5-1
643B-S1	7 & 9	12.5 Ω	5 ma	950524	SE221-1				3.5 ma				5-1
643KB-S1	7 & 9	12.5 Ω	5 ma	950524	SE221-1	Selected Narda 3044-10 (10 db)	950541	950558	3.5 ma			RF Cable 950356B-1	5-1
644B	7 & 9	12.5 Ω	5 ma	950371	SE209-1				3.5 ma				5-1
644KB	7 & 9	12.5 Ω	5 ma	950371	SE209-1	Narda 2846 (10 db)	950541	950543	3.5 ma	RF Cable 950357B-1			5-1
645B	7 & 9	12.5 Ω	5 ma	950430	SE209A-2				3.5 ma			Extension 950622B	5-1
645KB	7 & 9	12.5 Ω	5 ma	950430	SE209A-2	MDL 90FC106-1E (10 db)	950541	950544	3.5 ma		WG to Coax Adapter 253-1	Bend 950627B	5-1
645E	7 & 8	1.05 Ω	50 ma	950433	VA173A				30 ma	RF Cable 950357B-2 and Adapter 253-1		Extension 950622B	5-2
645KE	7 & 8	1.05 Ω	50 ma	950433	VA173A	MDL 90FC19-1E (17 db)	950541	950668	30 ma	RF Cable 950357B-1 and Adapter 253-1	WG to Coax Adapter 253-1	Bend 950627B	5-2
647E	7 & 8	1.05 Ω	50 ma	950330	VA162A				30 ma	Flexguide 254-7 and Extension 950564		Bend 950628B	5-2
648E	7 & 8	1.05 Ω	50 ma	950595	VA163A				30 ma	Flexguide 254-9		Extension 950355B	5-2
646B	7 & 9	12.5 Ω	5 ma	950698	SE220A-2				3.5 ma			Extension 950623B	5-1
649E	7 & 8	1.05 Ω	50 ma	950630	VA164A				30 ma	Flexguide 254-11		Extension 950612B	5-2

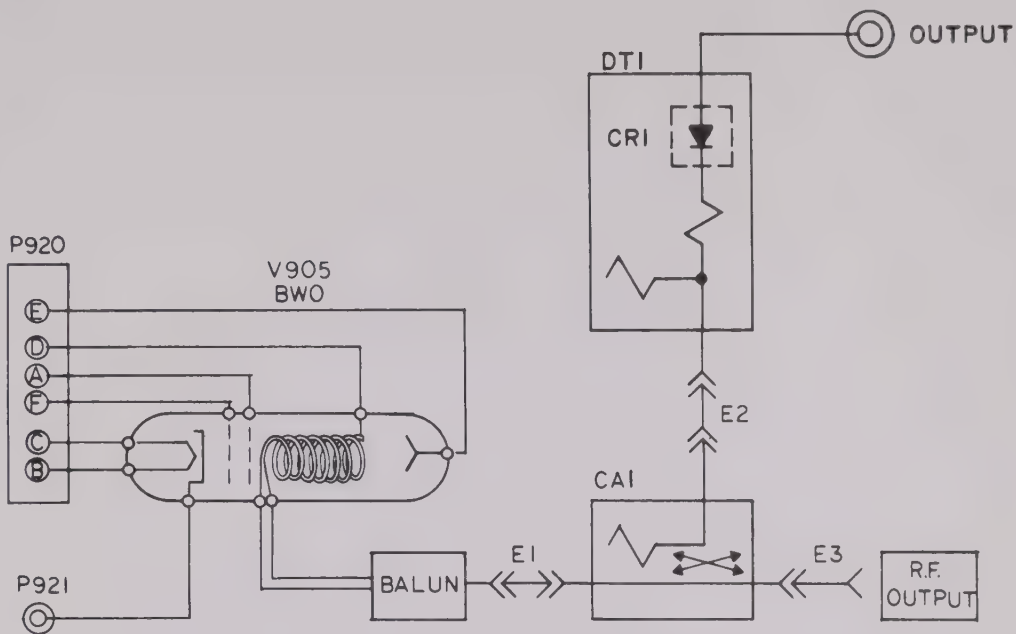


FIG. 5-1

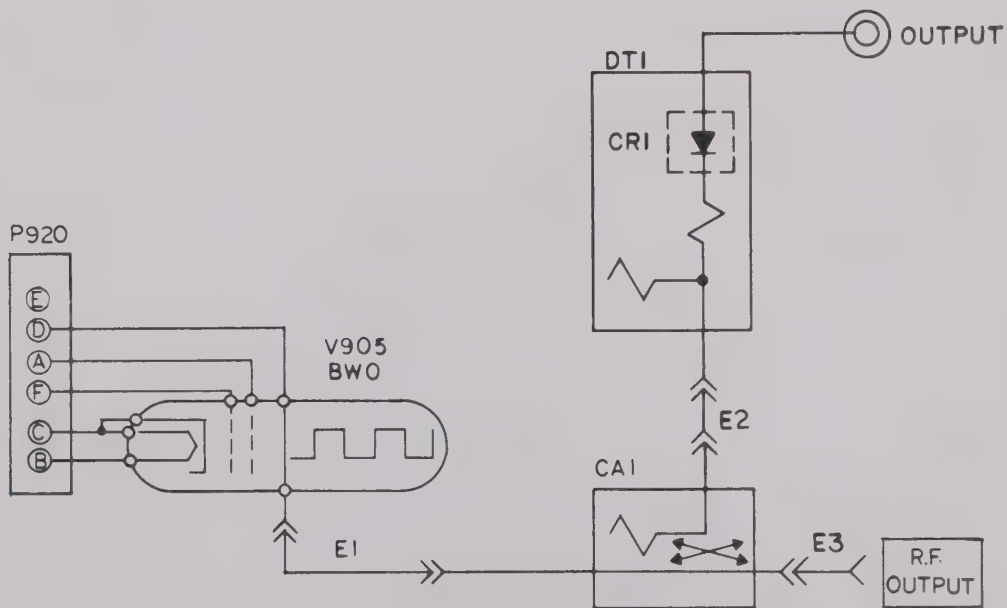


FIG. 5-2

SECTION 6

PARTS LIST

The following parts list is arranged in two groups: GROUP A contains those parts which are common to all 640's and GROUP B contains those parts which vary from model to model.

GROUP A

Capacitors

ALFRED
Part No.

C101	.01 mf	Fixed	Cer.	500 v	12-3
C102	.01 mf	Fixed	Cer.	500 v	12-3
C103	.002 mf	Fixed	Cer.	500 v	12-15
C104	.001 mf	Fixed	Cer.	500 v	12-2
C105	.1 mf	Fixed	Cer.	100 v	12-34
C106	.01 mf	Fixed	Cer.	500 v	12-3
C107	.1 mf	Fixed	Cer.	100 v	12-34
C108	.1 mf	Fixed	Cer.	100 v	12-34
C109	.1 mf	Fixed	Cer.	100 v	12-34
C110	.1 mf	Fixed	Cer.	100 v	12-34
C111	.01 mf	Fixed	Cer.	500 v	12-3
C112	27 pf	Fixed	Cer.	500 v	12-21
C113	.01 mf	Fixed	Cer.	500 v	12-3
C114	.1 mf	Fixed	Cer.	100 v	12-34
C201	.1 mf	Fixed	Cer.	100 v	12-34
C202	.1 mf	Fixed	Cer.	100 v	12-34
C203	100 mf	Fixed	Elec.	10 v dc	13-40
C204	10 mf	Fixed	Elec.	100 v dc	13-33
C205	.01 mf	Fixed	Cer.	500 v	12-3
C206	.01 mf	Fixed	Cer.	500 v	12-3
C301	.001 mf	Fixed	Cer.	500 v	12-2
C302	.01 mf	Fixed	Cer.	500 v	12-3
C303	.001 mf	Fixed	Cer.	500 v	12-2
C304					
C305	.01 mf	Fixed	Cer.	500 v	12-3
C306	.01 mf	Fixed	Cer.	500 v	12-3
C307	.01 mf	Fixed	Cer.	500 v	12-3
C308	390 pf	Fixed	Cer.	500 v	12-24
C309	.001 mf	Fixed	Cer.	500 v	12-2
C310	.022 mf	Fixed	Cer.	500 v	12-31
C312	24 pf	Fixed	Mica.	500 v	11-2
C401	.05 mf	Fixed	Cer.	75 v	12-9
C402	27 pf	Fixed	Cer.	500 v	12-21
C403	.05 mf	Fixed	Cer.	75 v	12-9
C404	27 pf	Fixed	Cer.	500 v	12-21
C405	.05 mf	Fixed	Cer.	75 v	12-9

Capacitors (continued)

ALFRED
Part No.

C406	27 pf	Fixed	Cer.	500 v	12-21
C501	.1 mf	Fixed	Cer.	100 v	12-34
C502	.01 mf	Fixed	Paper	200 v $\pm$ 2%	14-26
C503	.01 mf	Fixed	Paper	200 v $\pm$ 2%	14-26
C504	270 pf	Fixed	Cer.		12-27
C505	270 pf	Fixed	Cer.		12-27
C506	270 pf	Fixed	Cer.		12-27
C507	100 pf	Fixed	Cer.		12-22
C601	.1 mf	Fixed	Cer.	100 v	12-34
C602	.1 mf	Fixed	Cer.	100 v	12-34
C603	.1 mf	Fixed	Cer.	100 v	12-34
C604	5 mf	Fixed	Elect.	50 v	13-44
C605	50 mf	Fixed	Elect.	10 v	13-49
C606	5 mf	Fixed	Cer.	50 v	12-44
C607	.1 mf	Fixed	Cer.	100 v	12-34
C608	.05 mf	Fixed	Cer.	500 v	12-34
C609	not used				
C610	500 pf	Fixed	Cer.	1000 v	12-26
C701	10 mf	Fixed	Paper	200 v	14-23
C702	1 mf	Fixed	Paper	200 v	14-24
C703	.1 mf	Fixed	Paper	200 v	14-25
C704	.01 mf	Fixed	Paper	200 v	14-26
C750	.022 mf	Fixed	Cer.	500 v	12-31
C751	1000 pf	Fixed	Feed-thru	500 v	12-36
C752	.022 mf	Fixed	Cer.	500 v	12-31
C753	.1 mf	Fixed	Cer.	100 v	12-34
C754	100 pf	Fixed	Cer.	500 v	12-22
C755	100 pf	Fixed	Cer.	500 v	12-22
C756	39 pf	Fixed	Cer.	1000 v	12-42
C757	30 pf	Fixed	Cer.	6 Kv	12-12
C758	270 pf	Fixed	Cer.	1000 v	12-27
C759	30 pf	Fixed	Cer.	6 Kv	12-12
C760	27 pf	Fixed	Cer.	500 v	12-21
C761	5 pf	Fixed	Cer.	500 v	12-7
C762	not used				
C763	5 pf	Fixed	Cer.	500 v	12-7

Capacitors (continued)

ALFRED
Part No.

C764	.01 mf	Fixed	Cer.	600 v	12-3
C765	.01 mf	Fixed	Cer.	600 v	12-3
C766	1000 pf	Fixed	Feed thru	500 v	12-36
C801	.01 mf	Fixed	Cer.	500 v	12-3
C802	50 mf	Fixed	Elect.	25 v	13-49
C803	.1 mf	Fixed	Cer.	100 v	12-34
C804	10 mf	Fixed	Elect.	150 v	13-51
C805	10 mf	Fixed	Elect.	150 v	13-51
C806	.01 mf	Fixed	Cer.	500 v	12-3
C807	.01 mf	Fixed	Cer.	500 v	12-3
C808	1 mf	Fixed	Elect.	450 v	13-48
C901	150 mf/150 v, 100 mf/50 v	Fixed	Elect.		13-46
C902	100 mf	Fixed	Elect.	250 v	13-38
C903	40/30 mf	Fixed	Elect.	150 v	13-37
C904	.001 mf	Fixed	Cer.	6 K v	12-28
C905	.005 mf	Fixed	Cer.	1000 v	12-17
C906	.001 mf	Fixed	Cer.	6 K v	12-28
C907	2 mf	Fixed	Oil	2 K v	15-18
C908	2 mf	Fixed	Oil	2 K v	15-18
C909	.001 mf	Fixed	Cer.	6 K v	12-28
C910	100/100 mf	Fixed	Elect.	50 v	13-36
C911	100 mf	Fixed	Elect.	250 v	13-38
C912	1.5 pf	Fixed	Cer.	6 K v	12-30
C913	10 mf	Fixed	Elect.	450 v dc	13-42
C914	.001 mf	Fixed	Cer.	6 K v	12-28
C915	500 mf	Fixed	Elect.	25 v dc	13-35
C916	.005 mf	Fixed	Cer.	1000 v	12-17
C917	10 mf	Fixed	Elect.	450 v dc	13-42
C918	10 mf	Fixed	Elect.	450 v dc	13-42
C919					
C920	3000 mf	Fixed	Elect.	15 v	13-9
C921	.001 mf	Fixed	Cer.	6 K v	12-28
C922	not used				
C923	.1 mf	Fixed	Cer.	100 v	12-34

Diodes

ALFRED
Part No.

CR101	1N459	81-41
CR102	1N459	81-41
CR103	1N459	81-41
CR104	1N3041A, Zener	136-24
CR201	1N823	81-75
CR301	1N459	81-41
CR302	1N459	81-41
CR303	1N459	81-41
CR304	1N459	81-41
CR305	1N459	81-41
CR306	1N459	81-41
CR307	1N459	81-41
CR308	1N459	81-41
CR401	1N459	81-41
CR402	1N459	81-41
CR403	1N459	81-41
CR404	1N459	81-41
CR405	1N459	81-41
CR406	1N459	81-41
CR407	1N459	81-41
CR408	1N459	81-41
CR409	1N459	81-41
CR410	1N459	81-41
CR411	1N459	81-41
CR412	1N459	81-41
CR501	HD1811	81-60
CR502		
CR503	1N459	81-41
CR504	1N459	81-41
CR505	1N459	81-41
CR601	1N459	81-41
CR602	1N459	81-41
CR603	1N459	81-41

Diodes (continued)

		ALFRED Part No.
CR604	1N459	81-41
CR605		
CR701	1N459	81-41
CR750	HD1811	81-60
CR751	HD1811	81-60
CR801	1N752A, Zener, 5.6 A, 10%	81-77
CR802	1N823, Zener, 6.2 v	81-75
CR803	DI-46	81-20
CR804	1/4M15Z10	81-57
CR805	HR6.5	81-38
CR806	1N459	81-41
CR807	1N459	81-41
CR808	1N459	81-41
CR809	1N459	81-41
CR810	1N459	81-41
CR811	1N459	81-41
CR901	DI-46 or DI-26	81-20
CR902	DI-46 or DI-26	81-20
CR903	DI-46 or DI-26	81-20
CR904	DI-46 or DI-26	81-20
CR905	DI-46 or DI-26	81-20
CR906	DI-46 or DI-26	81-20
CR907	DI-46 or DI-26	81-20
CR908	D11154	81-69
CR909	DI-26	81-20
CR910	DI-26	81-20
CR911	DI-26	81-20
CR912	DI-26	81-20
CR913		
CR914	MR322R	81-93
CR915	MR322R	81-93

Diodes (continued)

		ALFRED Part No.
CR916	1N459	81-41
CR917	1N459	81-41
CR918	1N459	81-41

Transistors

		ALFRED Part No.
Q101	2N2484	81-85
Q102	2N706	81-92
Q103	2N706	81-92
Q104	2N706	81-92
Q105	2N706	81-92
Q106	2N706	81-92
Q107	2N699	81-72
Q108	2N699	81-72
Q109	2N706	81-92
Q110	2N2484	81-85
Q201		
Q202	2N697	81-71
Q203	2N404	81-51
Q204	2N404	81-51
Q205	2N706	81-92
Q206	2N706	81-92
Q207	2N404	81-51
Q208		
Q209	2N404	81-51
Q210	2N404	81-51
Q211	S6793	81-90
Q212	S6793	81-90
Q213	2N404	81-51
Q214	2N404	81-51
Q215	2N1540	81-74
Q216	2N697	81-71

Transistors (continued)

		ALFRED Part No.
Q301	2N697	81-71
Q302	2N706	81-92
Q303	2N697	81-71
Q304	S6793	81-90
Q305	2N706	81-92
Q306	2N404	81-51
Q307	2N699	81-72
Q308	2N706	81-92
Q309	2N706	81-92
Q310	2N404	81-51
Q311	2N404	81-51
Q312	2N706	81-92
Q313	2N706	81-92
Q314	2N706	81-92
Q315		
Q401	S6793	81-90
Q402	S6793	81-90
Q403	2N404	81-51
Q404	2N404	81-51
Q405	2N404	81-51
Q406	2N404	81-51
Q407	S6793	81-90
Q408	S6793	81-90
Q409	2N404	81-51
Q410	2N404	81-51
Q411	2N404	81-51
Q412	2N404	81-51
Q413	S6793	81-90
Q414	S6793	81-90
Q415	2N404	81-51
Q416	2N404	81-51
Q417	2N404	81-51
Q418	2N404	81-51
Q419	2N404	81-51

Transistors (continued)

		ALFRED Part No.
Q501	SS102	81-108
Q502	SS102	81-108
Q503	2N706	81-73
Q504	2N706	81-73
Q505	2N706	81-73
Q506	2N706	81-73
Q601	S6793	81-90
Q602	S6793	81-90
Q603	2N1499	81-32
Q604	2N1499	81-32
Q605	2N706	81-73
Q606	2N706	81-73
Q607	2N706	81-73
Q608	2N706	81-73
Q609	2N706	81-73
Q610	2N706	81-73
Q611	2N706	81-73
Q612	2N706	81-73
Q613	2N404	81-51
Q614	2N706	81-73
Q615	2N697	81-71
Q701	2N697	81-71
Q702	2N404	81-51
Q703	2N404	81-51
Q704	2N404	81-51
Q705	2N699	81-72
Q750	2N1499	81-32
Q751	2N706	81-73
Q752	2N706	81-73
Q801	2N697	81-71
Q802	2N404	81-51
Q803	2N699	81-72
Q804	2N404	81-51
Q805	2N404	

Transistors (continued)

			ALFRED Part No.
Q806	2N404		81-51
Q807	2N404		81-51
Q808	2N699		81-72
Q809	2N706		81-73
Q810	2N404		81-51
Q811	S6793		81-90
Q812	S6793		81-90
Q901	2N1537		81-89
Q902	2N1540		81-74
Q903	2N2147		81-86
Q904	2N2147		81-86

Resistors

						ALFRED Part No.
R101	22 K	1/2 w	Fixed	Comp.	10%	41-22 K
R102	22 K	1/2 w	Fixed	Comp.	10%	41-22 K
R103						
R104	470 Ω	1/2 w	Fixed	Comp.	10%	41-470 Ω
R105	2.2 K	1/2 w	Fixed	Comp.	10%	41-2.2 K
R106	2.2 K	1/2 w	Fixed	Comp.	10%	41-2.2 K
R107	470 Ω	1/2 w	Fixed	Comp.	10%	41-470 Ω
R108						
R109	39 Ω	1/2 w	Fixed	Comp.	10%	41-39 Ω
R110	3.9 K	2 w	Fixed	Comp.	10%	43-3.9 K
R111	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R112	3.9 K	1/2 w	Fixed	Comp.	10%	41-3.9 K
R113	1.2 K	1/2 w	Fixed	Comp.	10%	41-1.2 K
R114	27 K	1/2 w	Fixed	Comp.	10%	41-27 K
R115	4.7 K	1 w	Fixed	Comp.	10%	42-4.7 K
R116	15 K	1/2 w	Fixed	Metal Film	1/2%	57-15 K
R117	15 K	1/2 w	Fixed	Metal Film	1/2%	57-15 K
R118	15 K	1/2 w	Fixed	Metal Film	1/2%	57-15 K
R119	27 K	1/2 w	Fixed	Comp.	10%	41-27 K
R120	15 K	1/2 w	Fixed	Metal Film	1%	56-15 K

Resistors (continued)

						ALFRED Part No.
R121	5 K	Variable (Bourns 3067P-1-502)				71-65
R122	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R123	150 K	1/2 w	Fixed	Comp.	10%	41-150 K
R124	1.8 K	1/2 w	Fixed	Comp.	10%	41-1.8 K
R125	200 Ω	Variable (Bourns 3067P-1-201)				71-62
R126	1 K	1/2 w	Fixed	Metal Film	1%	56-1 K
R127	150 K	1/2 w	Fixed	Comp.	10%	41-150 K
R128	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R201						
R202	19.6 K	1/2 w	Fixed	Metal Film	1%	56-19.6 K
R203	10 Ω	1/2 w	Fixed	Comp.	10%	41-10 Ω
R204	19.6 K	1/2 w	Fixed	Metal Film	1%	56-19.6 K
R205	1.21 K	1/2 w	Fixed	Metal Film	1%	56-1.21 K
R206	10 K	2 w	Fixed	Comp.	5%	46-10 K
R207	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R208	19.6 K	1/2 w	Fixed	Metal Film	1%	56-19.6 K
R209	1.21 K	1/2 w	Fixed	Metal Film	1%	56-1.21 K
R210	1.5 K	1/2 w	Fixed	Comp.	10%	41-1.5 K
R211	8.2 K	1/2 w	Fixed	Comp.	10%	41-8.2 K
R212	820 Ω	1/2 w	Fixed	Comp.	10%	41-820 Ω
R213	750 Ω	1/2 w	Fixed	Metal Film	1%	56-750 Ω
R214	200 Ω	Variable (Borg)				71-90
R215	1 Ω	1/2 w	Fixed	BW	5%	44-1.0 Ω
R216	19.6 K	1/2 w	Fixed	Metal Film	1%	56-19.6 K
R217	330 Ω	1/2 w	Fixed	Comp.	10%	41-330 Ω
R218	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R219	1.21 K	1/2 w	Fixed	Metal Film	1%	56-1.21 K
R220	19.6 K	1/2 w	Fixed	Metal Film	1%	56-19.6 K
R221	19.6 K	1/2 w	Fixed	Metal Film	1%	56-19.6 K
R222	1.21 K	1/2 w	Fixed	Metal Film	1%	56-1.21 K
R223	2.2 K	1/2 w	Fixed	Comp.	10%	41-2.2 K
R224	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R225	4.99 K	1/2 w	Fixed	Metal Film	1%	56-4.99 K
R226	34 K	1/2 w	Fixed	Metal Film	1%	56-34 K
R227	470 Ω	1/2 w	Fixed	Comp.	10%	41-470 Ω

Resistors (continued)

						ALFRED Part No.
R228	10 Ω	1/2 w	Fixed	Comp.	10%	41-10 Ω
R229	39 Ω	1/2 w	Fixed	Comp.	10%	41-39 Ω
R230	3.83 K	1/2 w	Fixed	Metal Film	1%	56-3.83 K
R231	13.3 K	1/2 w	Fixed	Metal Film	1%	56-13.3 K
R232	100 Ω	1/2 w	Fixed	Comp.	10%	41-100 Ω
R233	100 Ω	1/2 w	Fixed	Comp.	10%	41-100 Ω
R235	10 Ω	1/2 w	Fixed	Comp.	10 %	41-10 Ω
R301	220 K	1/2 w	Fixed	Comp.	10%	41-220 K
R302	33 K	1/2 w	Fixed	Comp.	10%	41-33 K
R303	2.2 K	1/2 w	Fixed	Comp.	10%	41-2.2 K
R304	3.3 K	1/2 w	Fixed	Comp.	10%	41-3.3 K
R305	33 K	1/2 w	Fixed	Comp.	10%	41-33 K
R306	220 K	1/2 w	Fixed	Comp.	10%	41-220 K
R307	4.99 K	1/2 w	Fixed	Metal Film	1%	56-4.99 K
R308	12.1 K	1/2 w	Fixed	Metal Film	1%	56-12.1 K
R309	27 K	1/2 w	Fixed	Comp.	10%	41-27 K
R310	100 K	1/2 w	Fixed	Comp.	10%	41-100 K
R311	18 K	1/2 w	Fixed	Comp.	10%	41-18 K
R312	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R313	33 K	1/2 w	Fixed	Comp.	10%	41-33 K
R314	1.8 M	1/2 w	Fixed	Comp.	10%	41-1.8 M
R315	100 Ω	1/2 w	Fixed	Comp.	10%	41-100 Ω
R316	8.2 K	1/2 w	Fixed	Comp.	10%	41-8.2 K
R317	39 K	1/2 w	Fixed	Comp.	10%	41-39 K
R318	470 K	1/2 w	Fixed	Comp.	10%	41-470 K
R319	100 K	1/2 w	Fixed	Comp.	10%	41-100 K
R320	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R321	150 K	1/2 w	Fixed	Comp.	10%	41-150 K
R322	120 K	1/2 w	Fixed	Comp.	10%	41-120 K
R323	100 K	1/2 w	Fixed	Comp.	10%	41-100 K
R324	1 M	1/2 w	Fixed	Comp.	10%	41-1 M
R325	3.3 K	1/2 w	Fixed	Comp.	10%	41-3.3 K
R326	5.6 K	1/2 w	Fixed	Comp.	10%	41-5.6 K
R327	100 K	1/2 w	Fixed	Comp.	10%	41-100 K
R328	15 M	1/2 w	Fixed	Comp.	10%	41-15 M

Resistors (continued)

						ALFRED Part No.
R329	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R330	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R331	22 K	1/2 w	Fixed	Comp.	10%	41-22 K
R332	27 K	1/2 w	Fixed	Comp.	10%	41-27 K
R333	100 K	1/2 w	Fixed	Comp.	10%	41-100 K
R334	3.3 K	1/2 w	Fixed	Comp.	10%	41-3.3 K
R335	33 K	1/2 w	Fixed	Comp.	10%	41-33 K
R336	2.2 K	1/2 w	Fixed	Comp.	10%	41-2.2 K
R337	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R338	3.3 K	1/2 w	Fixed	Comp.	10%	41-3.3 K
R339	220 K	1/2 w	Fixed	Comp.	10%	41-220 K
R340	220 K	1/2 w	Fixed	Comp.	10%	41-220 K
R341	100 Ω	1/2 w	Fixed	Comp.	10%	41-100 Ω
R342	1.8 K	1/2 w	Fixed	Comp.	10%	41-1.8 K
R401	100 K	1/2 w	Fixed	Comp.	10%	41-100 K
R402	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R403	100 K	1/2 w	Fixed	Metal Film	1/2%	57-100 K
R404	100 K	1/2 w	Fixed	Metal Film	1/2%	57-100 K
R405	100 K	1/2 w	Fixed	Metal Film	1/2%	57-100 K
R406	1.8 K	1/2 w	Fixed	Comp.	10%	41-1.8 K
R407	5 K	Variable, 15 turn (Bourns 3067P-1-502)				71-65
R408	1 M	1/2 w	Fixed	Comp.	10%	41-1 M
R409	1.8 K	1/2 w	Fixed	Comp.	10%	41-1.8 K
R410	1 M	1/2 w	Fixed	Comp.	10%	41-1 M
R411	680 K	1/2 w	Fixed	Comp.	10%	41-680 K
R412	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R413	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R414	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R415	47 Ω	1/2 w	Fixed	Comp.	10%	41-47 Ω
R416	1 M	1/2 w	Fixed	Comp.	10%	41-1 M
R417	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R418	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R419	180 K	1/2 w	Fixed	Comp.	10%	41-180 K
R420	10 K	1/2 w	Fixed	Metal Film	1%	56-10 K

Resistors (continued)

ALFRED
Part No.

R421	4.99 K	1/2 w	Fixed	Metal Film	1%	56-4.99 K
R422	10 K	1/2 w	Fixed	Metal Film	1%	56-10 K
R423	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R424	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R425	not used					
R426	10 K	1/2 w	Fixed	Metal Film	1%	56-10 K
R427	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R428	100 K	1/2 w	Fixed	Metal Film	1/2%	57-100 K
R429	100 K	1/2 w	Fixed	Metal Film	1/2%	57-100 K
R430	100 K	1/2 w	Fixed	Metal Film	1/2%	57-100 K
R431	1 M	1/2 w	Fixed	Comp.	10%	41-1 M
R432	5 K	Variable, 15 turn (Bourns 3067P-1-502)				71-65
R433	1M	1/2 w	Fixed	Comp.	10%	41-1 M
R434	680 K	1/2 w	Fixed	Comp.	10%	41-680 K
R435	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R436	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R437	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R438	47 Ω	1/2 w	Fixed	Comp.	10%	41-47 Ω
R439	1 M	1/2 w	Fixed	Comp.	10%	41-1 M
R440	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R441	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R442	180 K	1/2 w	Fixed	Comp.	10%	41-180 K
R443	10 K	1/2 w	Fixed	Metal Film	1%	56-10 K
R444	4.99 K	1/2 w	Fixed	Metal Film	1%	56-4.99 K
R445	10 K	1/2 w	Fixed	Metal Film	1%	56-10 K
R446	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R447	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R448	2.2 K	1/2 w	Fixed	Comp.	10%	41-2.2 K
R449	10 K	1/2 w	Fixed	Metal Film	1%	56-10 K
R450	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R451	100 K	1/2 w	Fixed	Metal Film	1/2%	57-100 K
R452	100 K	1/2 w	Fixed	Metal Film	1/2%	57-100 K
R453	100 K	1/2 w	Fixed	Metal Film	1/2%	57-100 K
R454	1 M	1/2 w	Fixed	Comp.	10%	41-1 M
R455	5 K	Variable, 15 turn (Bourns 3067P-1-502)				71-65

Resistors (continued)

						ALFRED Part No.
R456	1 M	1/2 w	Fixed	Comp.	10%	41-1 M
R457	680 K	1/2 w	Fixed	Comp.	10%	41-680 K
R458	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R459	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R460	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R461	47 Ω	1/2 w	Fixed	Comp.	10%	41-47 Ω
R462	1 M	1/2 w	Fixed	Comp.	10%	41-1 M
R463	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R464	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R465	180 K	1/2 w	Fixed	Comp.	10%	41-180 K
R466	10 K	1/2 w	Fixed	Metal Film	1%	56-10 K
R467	4.99 K	1/2 w	Fixed	Metal Film	1%	56-4.99 K
R468	10 K	1/2 w	Fixed	Metal Film	1%	56-10 K
R469	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R470	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R471	not used					
R472	10 K	1/2 w	Fixed	Metal Film	1%	56-10 K
R473	18 K	1/2 w	Fixed	Comp.	10%	41-18 K
R474	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R475	150 K	1/2 w	Fixed	Comp.	10%	41-150 K
R476	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R501	150 Ω	1/2 w	Fixed	Comp.	10%	41-150 Ω
R502	2.2 K	1/2 w	Fixed	Comp.	10%	41-2.2 K
R503	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R504	56.2 K	1/2 w	Fixed	Comp.	1%	56-56.2 K
R505	56.2 K	1/2 w	Fixed	Comp.	1%	56-56.2 K
R506	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R507	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R508	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R509	22 K	1/2 w	Fixed	Comp.	10%	41-22 K
R510	22 K	1/2 w	Fixed	Comp.	10%	41-22 K
R511	8.2 K	1/2 w	Fixed	Comp.	10%	41-8.2 K
R512	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R513	15 K	1/2 w	Fixed	Comp.	10%	41-15 K

Resistors (continued)

ALFRED
Part No.

R514	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R515	220 Ω	1/2 w	Fixed	Comp.	10%	41-220 Ω
R516	47 K	1/2 w	Fixed	Comp.	10%	41-47 K
R517	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R518	47 K	1/2 w	Fixed	Comp.	10%	41-47 K
R519	6.8 K	1/2 w	Fixed	Comp.	10%	41-6.8 K
R520	68 K	1/2 w	Fixed	Comp.	10%	41-68 K
R521	8.2 K	1/2 w	Fixed	Comp.	10%	41-8.2 K
R522	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R523	3.3 K	1/2 w	Fixed	Comp.	10%	41-3.3 K
R524	1.2 K	1/2 w	Fixed	Comp.	10%	41-1.2 K
R525	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R526	10 K	1 w	Fixed	Comp.	10%	42-10 K
R527	33 K	1/2 w	Fixed	Comp.	10%	41-33 K
R528	6.8 K	1/2 w	Fixed	Comp.	10%	41-6.8 K
R529	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R530						
R601	330 K	1/2 w	Fixed	Comp.	10%	41-330 K
R602	3.3 K	1/2 w	Fixed	Comp.	10%	41-3.3 K
R603	5 K	Variable (15 turn)				71-94
R604	1.5 K	1/2 w	Fixed	Comp.	10%	41-1.5 K
R605	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R606	6.8 K	1/2 w	Fixed	Comp.	10%	41-6.8 K
R607	1.5 K	1/2 w	Fixed	Comp.	10%	41-1.5 K
R608	220 K	1/2 w	Fixed	Comp.	10%	41-220 K
R609	150 K	1/2 w	Fixed	Comp.	10%	41-150 K
R610	150 K	1/2 w	Fixed	Comp.	10%	41-150 K
R611	5 K	Variable, 15 turn				71-94
R612	5.6 K	1/2 w	Fixed	Comp.	10%	41-5.6 K
R613	47 Ω	1/2 w	Fixed	Comp.	10%	41-47 Ω
R614	47 Ω	1/2 w	Fixed	Comp.	10%	41-47 Ω
R615	5.6 K	1/2 w	Fixed	Comp.	10%	41-5.6 K
R616	8.2 K	1/2 w	Fixed	Comp.	10%	41-8.2 K
R617	3.3 K	1/2 w	Fixed	Comp.	10%	41-3.3 K

Resistors (continued)

						ALFRED Part No.
R618	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R619	8.2 K	1/2 w	Fixed	Comp.	10%	41-8.2 K
R620	2.7 K	1/2 w	Fixed	Comp.	10%	41-2.7 K
R621	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R622	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R623	4.7 K	1/2 w	Fixed	Comp.	10 %	41-4.7 K
R624	1.5 K	1/2 w	Fixed	Comp.	10%	41-1.5 K
R625	not used					
R626	*180 Ω	1/2 w	Fixed	Comp.	10%	41-180 Ω
R627	1.2 K	1/2 w	Fixed	Comp.	10%	41-1.2 K
R628	not used					
R629	330 K	1/2 w	Fixed	Comp.	10%	41-330 K
R630	1.5 K	1/2 w	Fixed	Comp.	10%	41-1.5 K
R631	1.5 K	1/2 w	Fixed	Comp.	10%	41-1.5 K
R632	1.5 K	1/2 w	Fixed	Comp.	10%	41-1.5 K
R633	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R634	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R635	390 Ω	1/2 w	Fixed	Comp.	10%	41-390 Ω
R636	470 Ω	1/2 w	Fixed	Comp.	10%	41-470 Ω
R637	3.3 K	1/2 w	Fixed	Comp.	10%	41-3.3 K
R638	not used					
R639	27 K	1/2 w	Fixed	Comp.	10%	41-27 K
R640	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R641	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R642	6.8 K	1/2 w	Fixed	Comp.	10%	41-6.8 K
R643	100 Ω	1/2 w	Fixed	Comp.	10%	41-100 Ω
R644	3.3 K	1/2 w	Fixed	Comp.	10%	41-3.3 K
R645	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R646	82 K	1/2 w	Fixed	Comp.	10%	41-82 K
R647	2.7 K	1/2 w	Fixed	Comp.	10%	41-2.7 K
R648	5.6 K	1/2 w	Fixed	Comp.	10%	41-5.6 K
R649	470 Ω	1/2 w	Fixed	Comp.	10%	41-470 Ω
R650	2.2 K	1/2 w	Fixed	Comp.	10%	41-2.2 K
R651	470 Ω	1/2 w	Fixed	Comp.	10%	41-470 Ω

*Factory Selected

Resistors (continued)

ALFRED
Part No.

R701	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R702	6.8 K	1/2 w	Fixed	Comp.	10%	41-6.8 K
R703	200 Ω	Variable (Bourns 3067P-1-201)				71-62
R704	56 K	1/2 w	Fixed	Comp.	10%	41-56 K
R705	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R706	1.78 K	1/2 w	Fixed	Metal Film	1%	56-1.78 K
R707	866 Ω	1/2 w	Fixed	Metal Film	1%	56-866 Ω
R708	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R709	200 Ω	Variable (Bourns 3067P-1-201)				71-62
R710	1.62 K	1/2 w	Fixed	Metal Film	1%	56-1.62 K
R711	27 K	1/2 w	Fixed	Comp.	10%	41-27 K
R712	not used					
R713	not used					
R714	49.9 Ω	1/2 w	Fixed	Metal Film	1%	56-49.9 Ω
R715	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R716	1 K	1/2 w	Fixed	Metal Film	1%	56-1 K
R717	3.9 K	2 w	Fixed	Comp.	10%	43-3.9 K
R718	8.2 K	2 w	Fixed	Comp.	10%	43-8.2 K
R719	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R750	100 Ω	1/2 w	Fixed	Comp.	10%	41-100 Ω
R751	100 Ω	1/2 w	Fixed	Comp.	10%	41-100 Ω
R752	470 Ω	1/2 w	Fixed	Comp.	10%	41-470 Ω
R753	2.2 K	1/2 w	Fixed	Comp.	10%	41-2.2 K
R754	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R755	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R756	5.6 K	1/2 w	Fixed	Comp.	10%	41-5.6 K
R757	47 Ω	1/4 w	Fixed	Comp.	10%	37-47 Ω
R758	47 Ω	1/4 w	Fixed	Comp.	10%	37-47 Ω
R759	47 Ω	1/4 w	Fixed	Comp.	10%	37-47 Ω
R760	47 Ω	1/4 w	Fixed	Comp.	10%	37-47 Ω
R761	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R762	470 Ω	1/2 w	Fixed	Comp.	10%	41-470 Ω
R801	39 Ω	1/2 w	Fixed	Comp.	10%	41-39 Ω
R802	39 Ω	1/2 w	Fixed	Comp.	10%	41-39 Ω

Resistors (continued)

ALFRED
Part No.

R803	470 Ω	1/2 w	Fixed	Comp.	10%	41-470 Ω
R804	150 Ω	1/2 w	Fixed	Comp.	10%	41-150 Ω
R805	100 Ω	Variable, 15 turn				71-61
R806	220 Ω	1/2 w	Fixed	Comp.	10%	41-220 Ω
R807	2.2 K	2 w	Fixed	Comp.	10%	43-2.2 K
R808	39 K	1/2 w	Fixed	Comp.	10%	41-39 K
R809	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R810	47 K	1/2 w	Fixed	Comp.	10%	41-47 K
R811	68 K	1/2 w	Fixed	Comp.	10%	41-68 K
R812	10 Ω	1/2 w	Fixed	Comp.	10%	41-10 Ω
R813	3.9 K	1/2 w	Fixed	Comp.	10%	41-3.9 K
R814	3.9 K	1/2 w	Fixed	Comp.	10%	41-3.9 K
R815	34 K	1/2 w	Fixed	Metal Film	1%	56-34 K
R816	8.25 K	1/2 w	Fixed	Metal Film	1%	56-8.25 K
R817	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R818	56 K	1/2 w	Fixed	Comp.	10%	41-56 K
R819	4.7 K	2 w	Fixed	Comp.	10%	43-4.7 K
R820	100 Ω	1/2 w	Fixed	Comp.	10%	41-100 Ω
R821	2 K	Variable, 15 turn				71-63
R822	100 K	1/2 w	Fixed	Comp.	10%	41-100 K
R823	23.7 K	1/2 w	Fixed	Metal Film	1%	56-23.7 K
R824	1.69 K	1/2 w	Fixed	Metal Film	1%	56-1.69 K
R825	220 K	1/2 w	Fixed	Comp.	10%	41-220 K
R826	4.7 K	1/2 w	Fixed	Comp.	10%	41-4.7 K
R827	not used					
R828	5 K	Variable, 15 turn				71-65
R829	17.8 K	1/2 w	Fixed	Metal Film	1%	56-17.8 K
R830	100 K	1/2 w	Fixed	Metal Film	1%	56-100 K
R831	not used					
R832	470 Ω	1/2 w	Fixed	Comp.	10%	41-470 Ω
R901	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R902	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R903	100 Ω	2 w	Fixed	Comp.	10%	43-100 Ω
R904	100 K	1/2 w	Fixed	Comp.	10%	41-100 K
R905	100 K	1/2 w	Fixed	Comp.	10%	41-100 K

Resistors (continued)

						ALFRED Part No.
R906	10 Ω	1/2 w	Fixed	Comp.	10%	41-10 Ω
R907	10 Ω	1/2 w	Fixed	Comp.	10%	41-10 Ω
R908	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R909	100 Ω	1/2 w	Fixed	Comp.	10%	41-100 Ω
R910	56 Ω	1/2 w	Fixed	Comp.	10%	41-56 Ω
R911	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R912	100 Ω	1/2 w	Fixed	Comp.	10%	41-100 Ω
R913	56 Ω	1/2 w	Fixed	Comp.	10%	41-56 Ω
R914	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R915	100 Ω	1/2 w	Fixed	Comp.	10%	41-100 Ω
R916	56 Ω	1/2 w	Fixed	Comp.	10%	41-56 Ω
R917	464 K	1 w	Fixed	Metal Film	1%	55-40
R918	464 K	1 w	Fixed	Metal Film	1%	55-40
R919	464 K	1 w	Fixed	Metal Film	1%	55-40
R920	464 K	1 w	Fixed	Metal Film	1%	55-40
R921	464 K	1 w	Fixed	Metal Film	1%	55-40
R922	464 K	1 w	Fixed	Metal Film	1%	55-40
R923	68 K	2 w	Fixed	Comp.	10%	43-68 K
R924	10 K	10 w	Fixed	W.W.	5%	62-1
R925	22 K	1/2 w	Fixed	Comp.	10%	41-22 K
R926	1 K	Variable, 10 turn, 1% Beckman				74-6
R927	1 K	Variable, 10 turn, 1% Beckman				74-6
R928	10 K	Variable			20%	71-82
R929	1 K	Variable, 10 turn, 1% Beckman				74-6
R930	100 Ω	Variable, 2 w, 10%				71-72
R931	1 K	Variable, 10 turn, 1% Beckman				74-6
R932	1 K	Variable, 10 turn, 1% Beckman				64-6
R933	12.5 Ω	1/2 w	Fixed	W.W.	1%	55-4
R934	10 Ω	1/2 w	Fixed	W.W.	1%	55-46
R935	not used					
R936	16.2 Ω	1/2 w	Fixed	Metal Film	1%	56-16.2 Ω
R937	10 K	Variable, 1/2 w			20%	71-77
R938	10 K	Variable, 20%				71-84
R939	200 K	2 w	Fixed	Metal Film	5%	52-200 K
R940	200 K	2 w	Fixed	Metal Film	5%	52-200 K

Resistors (continued)

						ALFRED Part No.
R941	200 K	2 w	Fixed	Metal Film	5%	52-200 K
R942	200 K	2 w	Fixed	Metal Film	5%	52-200 K
R943	200 K	2 w	Fixed	Metal Film	5%	52-200 K
R944	8 M	4 w, 5 K v	Fixed	Comp.	20%	61-22
R945	383 K	1/2 w	Fixed	Metal Film	1%	56-383 K
R946	5 M	Variable, 1/2 w, V taper			10%	71-71
R947	2.5 K	5 w	Fixed	W.W.	10%	61-13
R948	27 Ω	1/2 w	Fixed	Comp.	10%	41-27 Ω
R949	3.6 Ω	5 w	Fixed	W.W.	3%	61-15
R950	15 K	20 w	Fixed	W.W.	5%	63-11
R951	150 K	1/2 w	Fixed	Comp.	10%	41-150 K
R952	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R953	15 K	1 w	Fixed	Comp.	10%	42-15 K
R954	15 K	1 w	Fixed	Comp.	10%	42-15 K
R955	4.7 Ω	1 w	Fixed	Comp.	5%	45-4.7 Ω
R956	16.2 Ω	1/2 w	Fixed	Metal Film	1%	56-16.2 Ω
R957	16.2 Ω	1/2 w	Fixed	Metal Film	1%	56-16.2 Ω
R958	16.2 Ω	1/2 w	Fixed	Metal Film	1%	56-16.2 Ω
R959	16.2 Ω	1/2 w	Fixed	Metal Film	1%	56-16.2 Ω
R960	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R961	8.2 K	1/2 w	Fixed	Comp.	10%	41-8.2 K
R962	1 K	1/2 w	Fixed	Comp.	10%	41-1 K
R963	10 M	1/2 w	Fixed	Comp.	10%	41-10 M
R964	10 K	1/2 w	Fixed	Comp.	10%	41-10 K
R966	See Schematic 900669D					
R967	68 K	2 w	Fixed	Comp.	10 %	43-68 K

Inductors

			ALFRED Part No.
L750	1 mh, coil, RF		92-18
L751	.47 mh, coil, RF		92-17
L752	33 mh, coil, RF		92-5
L753	33 mh, coil, RF		92-5
L754	33 mh, coil, RF		92-5
L755	33 mh, coil, RF		92-5

Inductors (continued)

		ALFRED Part No.
L756	33 mh, coil, RF	92-5
L757	33 mh, coil, RF	92-5

Transformers

		ALFRED Part No.
T901	Tranex -4-0896 (ALFRED Spec. #950601)	91-195
T902	Tranex - 40588 (ALFRED Spec. #950202)	91-185

Relays

		ALFRED Part No.
K701	SPDT, 10 K coil (P & B R SSD)	106-24
K901	Time delay (Amperite 6N060)	106-25
K902	110 v dc, 3 PDT (P & B KA2270)	106-18
K903	110 v dc (P & B KA1466)	106-4

Switches

		ALFRED Part No.
S901	Pushbutton (Switchcraft 201)	101-18
S902	Rotary 630902 (rf output)	102-131
S903	Rotary 630903 (sweep time)	102-121
S904	Rotary 630904 (modulation)	102-129
S905	Rotary 630905 (sweep trigger)	102-122
S906	Rotary 630906 (frequency)	102-130
S907	not used	
S908	Toggle DPST	101-5
S909	Snap action (Cherry E33-20A)	101-17
S910	Snap action (Cherry E33-20A)	101-17
S911	Lever (630-911)	102-128
S912	Pushbutton (normally closed)	101-8

Switches (continued)

		ALFRED Part No.
S913	Slide (oak N.S. 278)	102-126
S914	Rotary 630914 (single frequency)	102-32
S915	Pushbutton (Switchcraft 963)	101-19

Vacuum Tubes

		ALFRED Part No.
V901	Tube, electron, 8068	111-8068
V902	Tube, electron, 8068	111-8068
V903	Tube, electron, 8068	111-8068
V904	Tube, electron, 6CW5	111-6CW5

Fuses

		ALFRED Part No.
F901	3 amp, 3 AG, 250 v	121-3
F902	8 amp, 3 AG, 250 v	121-8
F903	3 amp, 3 AG, 250 v	121-3

Bulbs

		ALFRED Part No.
DS901	Indicator, panel (Leecraft #32-1111T)	126-9
DS902	Indicator, panel (Leecraft #32-1111T)	126-9
DS903	Lamp, neon NE-2	126-1

Meters

		ALFRED Part No.
M901	Elapsed Time Indicator	87-1

GROUP B

PARTS WHICH VARY FROM MODEL TO MODEL

641-B and 641K-B

Resistors

ALFRED
Part No.

R10	127 K	1/2 w	Fixed	Metal Film	1%	56-127 K
R11	178 K	1/2 w	Fixed	Metal Film	1%	56-178 K
R12	422 K	1/2 w	Fixed	Metal Film	1%	56-422 K
R13	412 K	1/2 w	Fixed	Metal Film	1%	56-412 K
R14	487 K	1/2 w	Fixed	Metal Film	1%	56-487 K
R15	536 K	1/2 w	Fixed	Metal Film	1%	56-536 K
R16	402 K	1/2 w	Fixed	Metal Film	1%	56-402 K
R17	392 K	1/2 w	Fixed	Metal Film	1%	56-392 K
R18	324 K	1/2 w	Fixed	Metal Film	1%	56-324 K
R19	511 K	1/2 w	Fixed	Metal Film	1%	56-511 K
R20	383 K	1/2 w	Fixed	Metal Film	1%	56-383 K
R21	18 K	1/2 w	Fixed	Comp.	10%	41-18 K
R22	47 K	1/2 w	Fixed	Comp.	10%	41-47 K
R23	750 Ω	1/2 w	Fixed	Metal Film	1%	56-750 Ω
R24	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R25	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R26	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R27	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R28	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R29	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R30	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R31	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R32	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω

Diodes

ALFRED
Part No.

CR11	1N459	81-41
CR12	1N459	81-41
CR13	1N459	81-41
CR14	1N459	81-41
CR15	1N459	81-41

641-B and 641K-B

Diodes (continued)

		ALFRED Part No.
CR16	1N459	81-41
CR17	1N459	81-41
CR18	1N459	81-41
CR19	1N459	81-41
CR20	1N459	81-41
CR21	1N459	81-41
CR22	1N459	81-41

641-B-S1 and 641K-B-S1

Resistors

						ALFRED Part No.
R10	90.9 K	1/2 w	Fixed	Metal Film	1%	56-90.9 K
R11	187 K	1/2 w	Fixed	Metal Film	1%	56-187 K
R12	487 K	1/2 w	Fixed	Metal Film	1%	56-487 K
R13	576 K	1/2 w	Fixed	Metal Film	1%	56-576 K
R14	475 K	1/2 w	Fixed	Metal Film	1%	56-475 K
R15	392 K	1/2 w	Fixed	Metal Film	1%	56-392 K
R16	365 K	1/2 w	Fixed	Metal Film	1%	56-365 K
R17	604 K	1/2 w	Fixed	Metal Film	1%	56-604 K
R18	324 K	1/2 w	Fixed	Metal Film	1%	56-324 K
R19	316 K	1/2 w	Fixed	Metal Film	1%	56-316 K
R20	464 K	1/2 w	Fixed	Metal Film	1%	56-464 K
R21	18 K	1/2 w	Fixed	Comp.	10%	41-18 K
R22	33 K	1/2 w	Fixed	Comp.	10%	41-33 K
R23	750 Ω	1/2 w	Fixed	Metal Film	1%	56-750 Ω
R24	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R25	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R26	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R27	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R28	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R29	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R30	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω

641-B-S1 and 641K-B-S1

Resistors (continued)

						ALFRED Part No.
R31	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R32	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω

Diodes

						ALFRED Part No.
CR11			1N459			81-41
CR12			1N459			81-41
CR13			1N459			81-41
CR14			1N459			81-41
CR15			1N459			81-41
CR16			1N459			81-41
CR17			1N459			81-41
CR18			1N459			81-41
CR19			1N459			81-41
CR20			1N459			81-41
CR21			1N459			81-41

642-B and 642K-B

Resistors

						ALFRED Part No.
R10	124 K	1/2 w	Fixed	Metal Film	1%	56-124 K
R11	133 K	1/2 w	Fixed	Metal Film	1%	56-133 K
R12	374 K	1/2 w	Fixed	Metal Film	1%	56-374 K
R13	332 K	1/2 w	Fixed	Metal Film	1%	56-332 K
R14	301 K	1/2 w	Fixed	Metal Film	1%	56-301 K
R15	267 K	1/2 w	Fixed	Metal Film	1%	56-267 K
R16	274 K	1/2 w	Fixed	Metal Film	1%	56-274 K
R17	261 K	1/2 w	Fixed	Metal Film	1%	56-261 K
R18	147 K	1/2 w	Fixed	Metal Film	1%	56-147 K
R19	249 K	1/2 w	Fixed	Metal Film	1%	56-249 K
R20	191 K	1/2 w	Fixed	Metal Film	1%	56-191 K

642-B and 642K-B

Resistors (continued)

						ALFRED Part No.
R21	12 K	1/2 w	Fixed	Comp.	10%	41-12 K
R22	47 K	1/2 w	Fixed	Comp.	10%	41-47 K
R23	750 Ω	1/2 w	Fixed	Metal Film	1%	56-750 Ω
R24	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R25	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R26	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R27	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R28	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R29	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R30	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R31	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R32	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω

Diodes

		ALFRED Part No.
CR11	1N459	81-41
CR12	1N459	81-41
CR13	1N459	81-41
CR14	1N459	81-41
CR15	1N459	81-41
CR16	1N459	81-41
CR17	1N459	81-41
CR18	1N459	81-41
CR19	1N459	81-41
CR20	1N459	81-41
CR21	1N459	81-41

643-B and 643K-B

Resistors

ALFRED
Part No.

R10	133 K	1/2 w	Fixed	Metal Film	1%	56-133 K
R11	137 K	1/2 w	Fixed	Metal Film	1%	56-137 K
R12	348 K	1/2 w	Fixed	Metal Film	1%	56-348 K
R13	309 K	1/2 w	Fixed	Metal Film	1%	56-309 K
R14	332 K	1/2 w	Fixed	Metal Film	1%	56-332 K
R15	261 K	1/2 w	Fixed	Metal Film	1%	56-261 K
R16	232 K	1/2 w	Fixed	Metal Film	1%	56-232 K
R17	237 K	1/2 w	Fixed	Metal Film	1%	56-237 K
R18	124 K	1/2 w	Fixed	Metal Film	1%	56-124 K
R19	237 K	1/2 w	Fixed	Metal Film	1%	56-237 K
R20	not used					
R21	12 K	1/2 w	Fixed	Comp.	10%	41-12 K
R22	47 K	1/2 w	Fixed	Comp.	10%	41-47 K
R23	750 Ω	1/2 w	Fixed	Metal Film	1%	56-750 Ω
R24	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R25	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R26	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R27	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R28	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R29	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R30	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R31	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R32	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω

Diodes

ALFRED
Part No.

CR11	1N459	81-41
CR12	1N459	81-41
CR13	1N459	81-41
CR14	1N459	81-41
CR15	1N459	81-41

643-B and 643K-B

Diodes (continued)

			ALFRED Part No.
CR16	1N459		81-41
CR17	1N459		81-41
CR18	1N459		81-41
CR19	1N459		81-41
CR20	1N459		81-41
CR21	1N459		81-41

643-B-S1 and 643K-B-S1

Resistors

						ALFRED Part No.
R10	100 K	1/2 w	Fixed	Metal Film	1%	56-100 K
R11	124 K	1/2 w	Fixed	Metal Film	1%	56-124 K
R12	287 K	1/2 w	Fixed	Metal Film	1%	56-287 K
R13	357 K	1/2 w	Fixed	Metal Film	1%	56-357 K
R14	324 K	1/2 w	Fixed	Metal Film	1%	56-324 K
R15	243 K	1/2 w	Fixed	Metal Film	1%	56-243 K
R16	261 K	1/2 w	Fixed	Metal Film	1%	56-261 K
R17	237 K	1/2 w	Fixed	Metal Film	1%	56-237 K
R18	205 K	1/2 w	Fixed	Metal Film	1%	56-205 K
R19	169 K	1/2 w	Fixed	Metal Film	1%	56-169 K
R20	200 K	1/2 w	Fixed	Metal Film	1%	56-200 K
R21	12 K	1/2 w	Fixed	Comp.	10%	41-12 K
R22	39 K	1/2 w	Fixed	Comp.	10%	41-39 K
R23	750 Ω	1/2 w	Fixed	Metal Film	1%	56-750 Ω
R24	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R25	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R26	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R27	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R28	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R29	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R30	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω

643-B-S1 and 643K-B-S1

Resistors (continued)

						ALFRED Part No.
R31	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R32	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω

Diodes

						ALFRED Part No.
CR11			1N459			81-41
CR12			1N459			81-41
CR13			1N459			81-41
CR14			1N459			81-41
CR15			1N459			81-41
CR16			1N459			81-41
CR17			1N459			81-41
CR18			1N459			81-41
CR19			1N459			81-41
CR20			1N459			81-41
CR21			1N459			81-41

644-B and 644K-B

Resistors

						ALFRED Part No.
R10	118 K	1/2 w	Fixed	Metal Film	1%	56-118 K
R11	412 K	1/2 w	Fixed	Metal Film	1%	56-412 K
R12	681 K	1/2 w	Fixed	Metal Film	1%	56-681 K
R13	523 K	1/2 w	Fixed	Metal Film	1%	56-523 K
R14	604 K	1/2 w	Fixed	Metal Film	1%	56-604 K
R15	536 K	1/2 w	Fixed	Metal Film	1%	56-536 K
R16	422 K	1/2 w	Fixed	Metal Film	1%	56-422 K
R17	422 K	1/2 w	Fixed	Metal Film	1%	56-422 K
R18	332 K	1/2 w	Fixed	Metal Film	1%	56-332 K
R19	332 K	1/2 w	Fixed	Metal Film	1%	56-332 K
R20	237 K	1/2 w	Fixed	Metal Film	1%	56-237 K

644-B and 644K-B

Resistors (continued)

						ALFRED Part No.
R21	12 K	1/2 w	Fixed	Comp.	10%	41-12 K
R22	47 K	1/2 w	Fixed	Comp.	10%	41-47 K
R23	750 Ω	1/2 w	Fixed	Metal Film	1%	56-750 Ω
R24	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R25	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R26	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R27	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R28	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R29	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R30	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R31	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R32	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω

Diodes

		ALFRED Part No.
CR11	1N459	81-41
CR12	1N459	81-41
CR13	1N459	81-41
CR14	1N459	81-41
CR15	1N459	81-41
CR16	1N459	81-41
CR17	1N459	81-41
CR18	1N459	81-41
CR19	1N459	81-41
CR20	1N459	81-41
CR21	1N459	81-41

645-B and 645K-B

Resistors

						ALFRED Part No.
R10	80.6 K	1/2 w	Fixed	Metal Film	1%	56-80.6 K
R11	221 K	1/2 w	Fixed	Metal Film	1%	56-221 K
R12	442 K	1/2 w	Fixed	Metal Film	1%	56-442 K
R13	402 K	1/2 w	Fixed	Metal Film	1%	56-402 K
R14	309 K	1/2 w	Fixed	Metal Film	1%	56-309 K
R15	287 K	1/2 w	Fixed	Metal Film	1%	56-287 K

645-B and 645K-B

Resistors (continued)

						ALFRED Part No.
R16	274 K	1/2 w	Fixed	Metal Film	1%	56-274 K
R17	200 K	1/2 w	Fixed	Metal Film	1%	56-200 K
R18	205 K	1/2 w	Fixed	Metal Film	1%	56-205 K
R19	165 K	1/2 w	Fixed	Metal Film	1%	56-165 K
R20	137 K	1/2 w	Fixed	Metal Film	1%	56-137 K
R21	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R22	33 K	1/2 w	Fixed	Comp.	10%	41-33 K
R23	750 Ω	1/2 w	Fixed	Metal Film	1%	56-750 Ω
R24	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R25	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R26	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R27	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R28	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R29	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R30	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R31	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R32	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω

Diodes

		ALFRED Part No.
CR11	1N459	81-41
CR12	1N459	81-41
CR13	1N459	81-41
CR14	1N459	81-41
CR15	1N459	81-41
CR16	1N459	81-41
CR17	1N459	81-41
CR18	1N459	81-41
CR19	1N459	81-41
CR20	1N459	81-41
CR21	1N459	81-41

645-E and 645K-E

Resistors

						ALFRED Part No.
R10	127 K	1/2 w	Fixed	Metal Film	1%	56-127 K
R11	412 K	1/2 w	Fixed	Metal Film	1%	56-412 K
R12	576 K	1/2 w	Fixed	Metal Film	1%	56-576 K
R13	not used					
R14	332 K	1/2 w	Fixed	Metal Film	1%	56-332 K
R15	487 K	1/2 w	Fixed	Metal Film	1%	56-487 K
R16	412 K	1/2 w	Fixed	Metal Film	1%	56-412 K
R17	412 K	1/2 w	Fixed	Metal Film	1%	56-412 K
R18	249 K	1/2 w	Fixed	Metal Film	1%	56-249 K
R19	365 K	1/2 w	Fixed	Metal Film	1%	56-365 K
R20	309 K	1/2 w	Fixed	Metal Film	1%	56-309 K
R21	15 K	1/2 w	Fixed	Comp.	10%	41-15 K
R22	56 K	1/2 w	Fixed	Comp.	10%	41-56 K
R23	750 Ω	1/2 w	Fixed	Metal Film	1%	56-750 Ω
R24	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R25	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R26	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R27	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R28	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R29	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R30	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R31	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R32	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω

Diodes

		ALFRED Part No.
CR11	1N459	81-41
CR12	1N459	81-41
CR13	1N459	81-41
CR14	1N459	81-41
CR15	1N459	81-41

645-E and 645K-E

Diodes (continued)

		ALFRED Part No.
CR16	1N459	81-41
CR17	1N459	81-41
CR18	1N459	81-41
CR19	1N459	81-41
CR20	1N459	81-41
CR21	1N459	81-41

647E

Resistors

						ALFRED Part No.
R10	133K	1/2 w	Fixed	Metal Film	1%	56-133 K
R11	not used					
R12	1.40 M	1/2 w	Fixed	Metal Film	1%	56-1.40 M
R13	768 K	1/2 w	Fixed	Metal Film	1%	56-768 K
R14	1.40 M	1/2 w	Fixed	Metal Film	1%	56-1.40 M
R15	604 K	1/2 w	Fixed	Metal Film	1%	56-604 K
R16	866 K	1/2 w	Fixed	Metal Film	1%	56-866 K
R17	536 K	1/2 w	Fixed	Metal Film	1%	56-536 K
R18	590 K	1/2 w	Fixed	Metal Film	1%	56-590 K
R19	715 K	1/2 w	Fixed	Metal Film	1%	56-715 K
R20	604 K	1/2 w	Fixed	Metal Film	1%	56-604 K
R21	47 K	1/2 w	Fixed	Comp.	10%	41-47 K
R22	56 K	1/2 w	Fixed	Comp.	10%	41-56 K
R23	750 Ω	1/2 w	Fixed	Metal Film	1%	56-750 Ω
R24	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R25	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R26	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R27	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R28	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R29	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R30	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω

647E

Resistors (continued)

						ALFRED Part No.
R31	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω
R32	100 Ω	1/2 w	Fixed	Metal Film	1%	56-100 Ω

Diodes

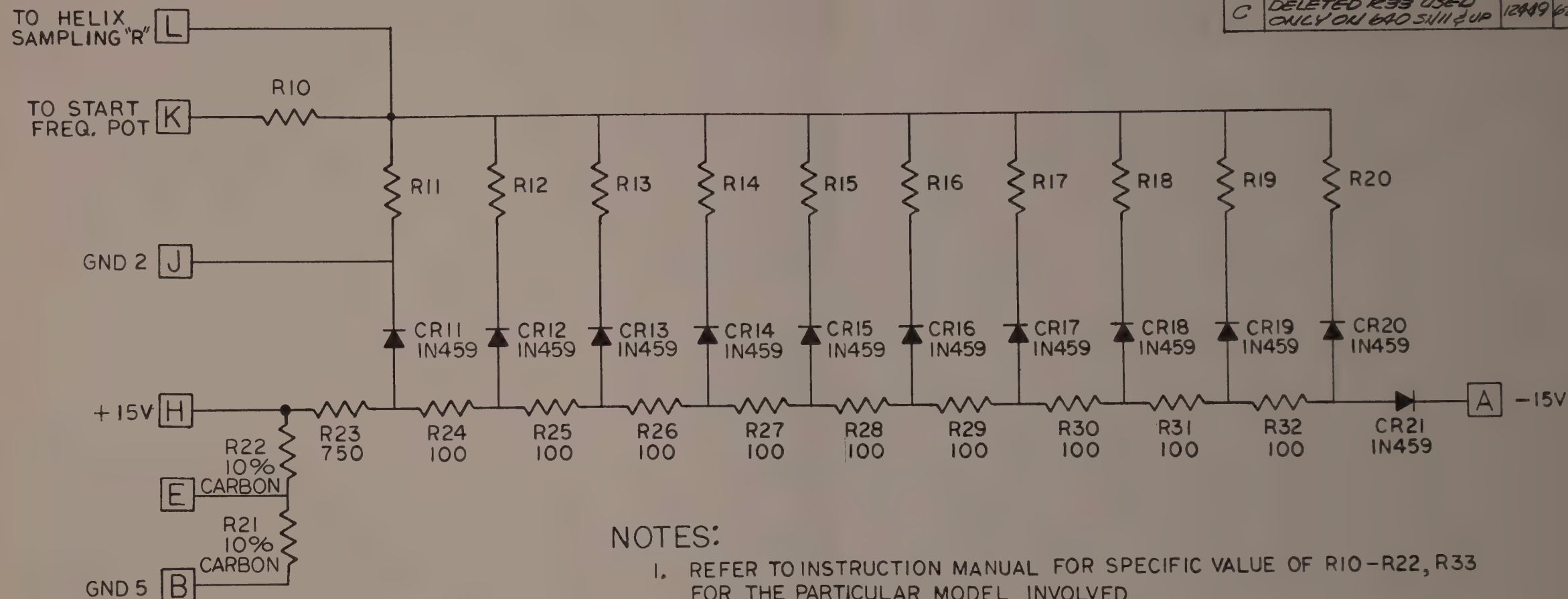
				ALFRED Part No.
CR11			1N459	81-41
CR12			1N459	81-41
CR13			1N459	81-41
CR14			1N459	81-41
CR15			1N459	81-41
CR16			1N459	81-41
CR17			1N459	81-41
CR18			1N459	81-41
CR19			1N459	81-41
CR20			1N459	81-41
CR21			1N459	81-41

SECTION 7

SCHEMATICS

Circuit	PC Board Number	Reference Designation Prefix	Schematic Number
Diode Shaper	10	10	900604B
Cathode Supply	100	100	900599C
Low Voltage Power Supplies	200	200	900718C
Sweep Circuit	300	300	900600C
Markers Circuit	400	400	900652C
Square Wave and Modulator	500	500	900678C
Leveler Circuit	600	600	900721C
Helix Overcurrent	700	700	900598C
Transfer Oscillator	750	750	900675C
Elevated Supply	800	800	900677C
Chassis	-	900	900669D

SYM	DESCRIPTION	NO.	DATE	BY
A	APPD. FOR PRODUCTION	~	9-25-63	D.P.
B	ADDED USAGE ON 640 ADDED R33 & * EFFECTIVE ON ALL SER. NO.	~	12-19-63	D.P.
C	DELETED R33 USED ONLY ON 640 S111 & UP	12449	6-29-64	V.L.



NOTES:

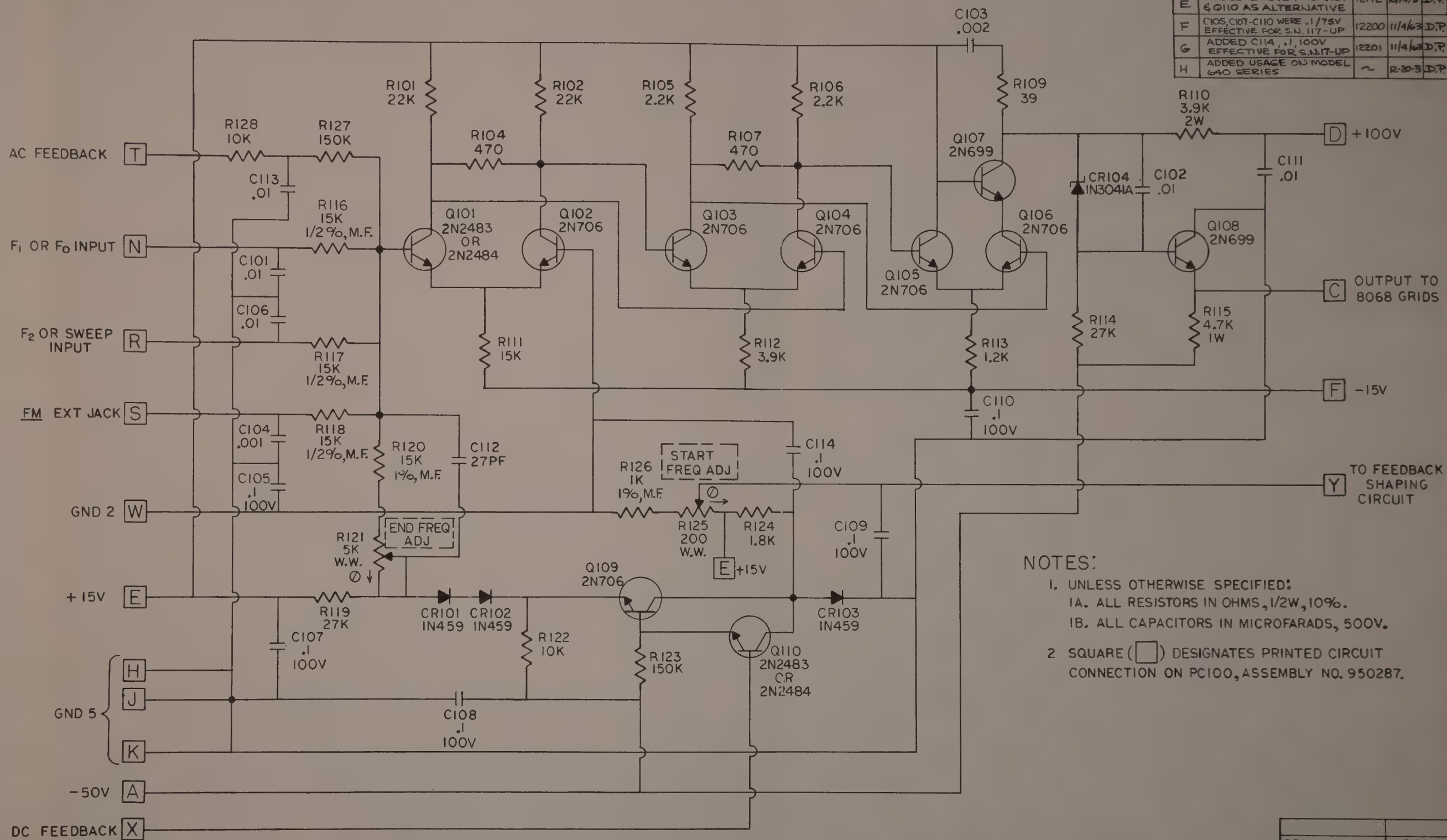
- REFER TO INSTRUCTION MANUAL FOR SPECIFIC VALUE OF R10-R22, R33 FOR THE PARTICULAR MODEL INVOLVED.
- UNLESS OTHERWISE SPECIFIED:
2A. ALL RESISTORS IN OHMS, 1/2W, 1%, METAL FILM.
- SQUARE () DESIGNATES PRINTED CIRCUIT CONNECTION ON PC900.

ITEM	REQD	PART NO.	DESCRIPTION
LIST OF MATERIAL			
MATERIAL		DRAWN <i>Dave Presley</i>	DATE 9-25-63
		ENG. <i>Ralph Bilton</i>	9/30/63
MATERIAL STOCK NO.		PROD. <i>Alan D. Sullivan</i>	9-30-63
FINISH OR TREATMENT			
		SCALE	

SCHEMATIC - DIODE SHAPER

DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± 1/2°
UNLESS INDICATED OTHERWISE

SER. NO. 11-UP	640
SER. NO. 18-UP	630
NEXT ASSY	USED ON
ALFRED ELECTRONICS PALO ALTO, CALIFORNIA	
900604B	
SHEET 1	OF 1



SYM	DESCRIPTION	NO.	DATE	BY
A	APPD. FOR PRODUCTION	—	9/10/63	D.P.
B	C103 WAS .002, R109 WAS 150K	12140	9/10/63	D.P.
C	R120 WAS 12.1K	12155	9/23/63	D.P.
D	C103 WAS .005	12156	9/24/63	D.P.
E	ADDED 2N2484 TO Q101 & Q110 AS ALTERNATIVE	12172	10/14/63	D.P.
F	C105, C107-C110 WERE .1/75V EFFECTIVE FOR S.N. 117-UP	12200	11/14/63	D.P.
G	ADDED C114, .1, 100V EFFECTIVE FOR S.N. 117-UP	12201	11/14/63	D.P.
H	ADDED USAGE ON MODEL 640 SERIES	~	12-20-63	D.P.

NOTES:

- UNLESS OTHERWISE SPECIFIED:
1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
1B. ALL CAPACITORS IN MICROFARADS, 500V.
- SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC100, ASSEMBLY NO. 950287.

ITEM	REQD	PART NO.	DESCRIPTION		SER. NO. 11-UP	640
					SER. NO. 17-UP	630
LIST OF MATERIAL					NEXT ASSY	USED ON
MATERIAL		DRAWN	DATE	SCHEMATIC - CATHODE SUPPLY	ALFRED ELECTRONICS PALO ALTO, CALIFORNIA	
DRAWN		7-1-63				
ENG		9-10-63				
PROD		9-10-63				
MATERIAL STOCK NO.				DIMENSIONS ARE IN INCHES TOL: .XX ± .015, .XXX ± .005, ANGLE ± W° UNLESS INDICATED OTHERWISE	900599C	
FINISH OR TREATMENT						
SCALE				SHEET OF		

SCHEMATIC -
CATHODE SUPPLY

SERIES
TRANSISTOR
Q903 COLLECTOR [H]

SERIES
TRANSISTOR
Q903 BASE [J]

GND 2 [K]

GND 5 [X]

SERIES
TRANSISTOR
Q904 BASE [T]

-15V INPUT
SUPPLY (-) [W]

SERIES
TRANSISTOR
Q904 EMITTER [S]

SERIES
TRANSISTOR
Q901 BASE [P]

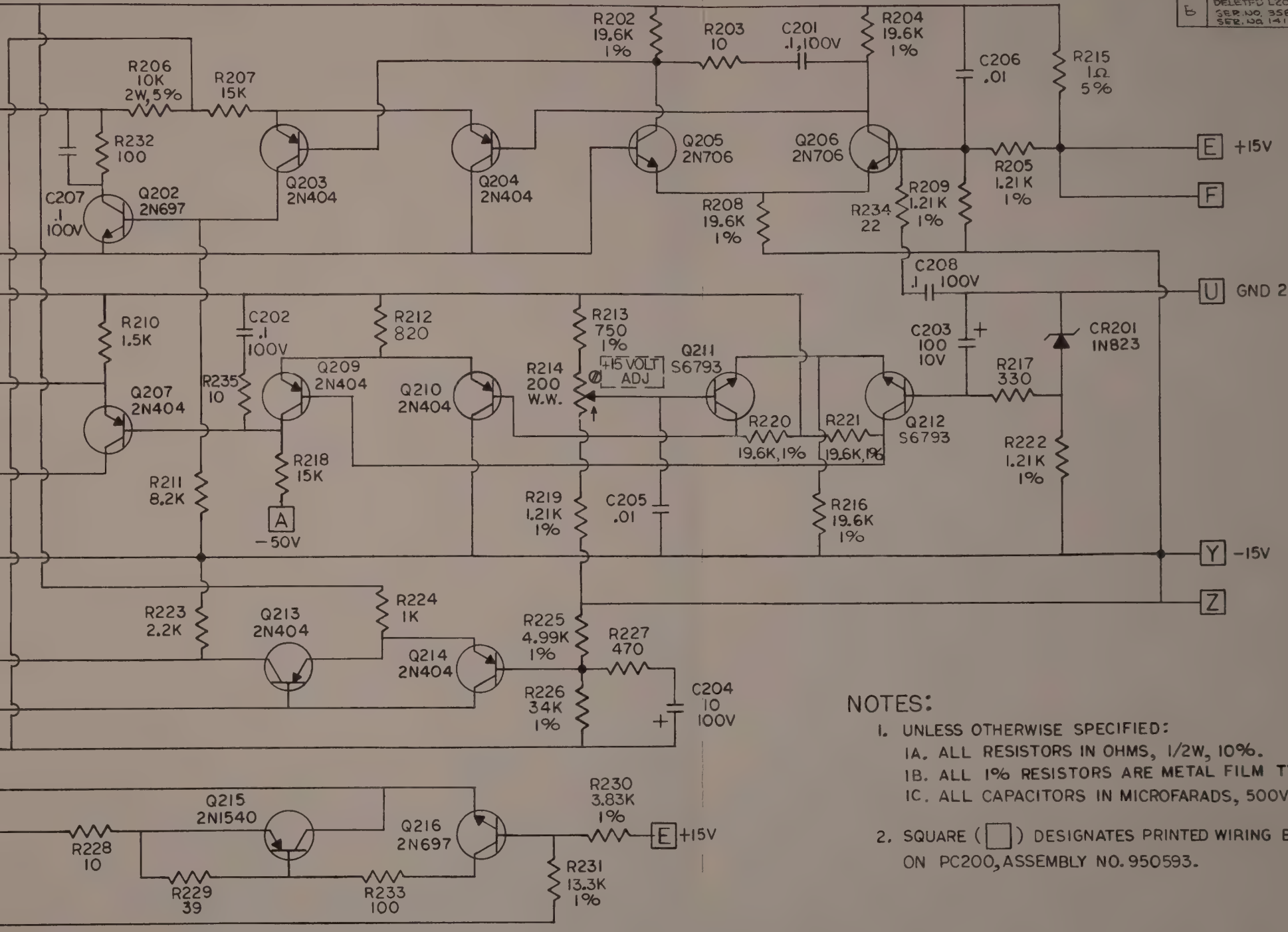
GND 4 [R]

+100V [V]

GND 3 [D]

-50 INPUT
SUPPLY (+) [C]

-50V [A]



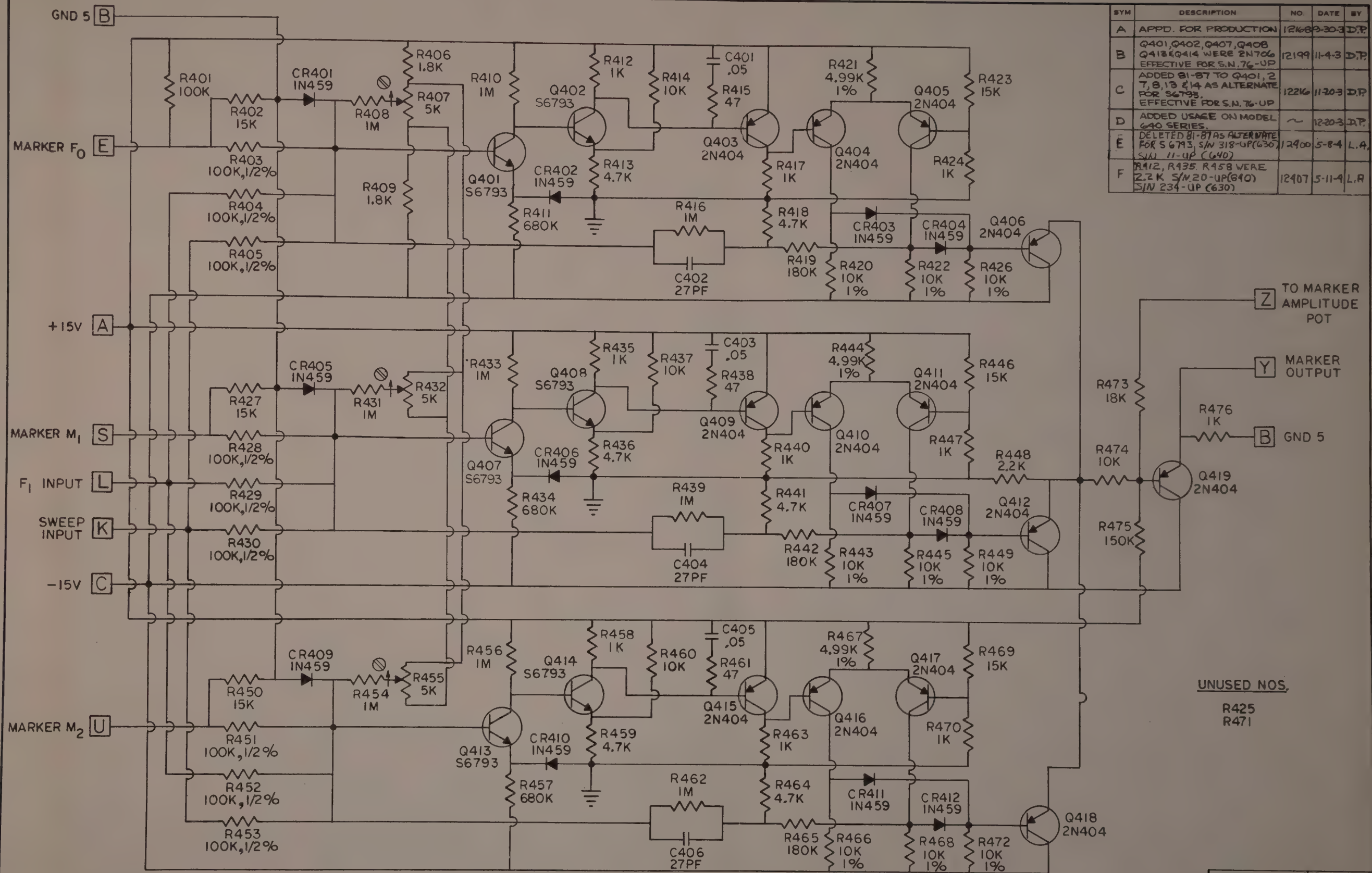
NOTES:

- UNLESS OTHERWISE SPECIFIED:
 - ALL RESISTORS IN OHMS, 1/2W, 10%.
 - ALL 1% RESISTORS ARE METAL FILM TYPE.
 - ALL CAPACITORS IN MICROFARADS, 500V.
- SQUARE (□) DESIGNATES PRINTED WIRING BOARD CONNECTION ON PC200, ASSEMBLY NO. 950593.

SYM	DESCRIPTION	NO.	DATE	BY
A	APPD. FOR PRODUCTION SUPP. CEDES # 900593C Q211 & Q212 WERE 2N404. REVERSED POLARITY OF Q211 & Q212, R212 WAS 2.2K. ASSY NO. WAS 950275. SER. NO. 358-UP (630) SER. NO. 141-UP (640)	12412A	6-27-64	D.P.
B	DELETED L202, ADDED R235 SER. NO. 358-UP (630) SER. NO. 141-UP (640)	12412C 12412B	10-12-64 9-25-64	D.P.

ITEM	REQD	PART NO.	DESCRIPTION
LIST OF MATERIAL			
MATERIAL		DRAWN Dave Presley 6-13-63	DATE
		ENG Ralph Butler 9-10-63	
		PROD Ron A. Andrews 9-10-63	
MATERIAL STOCK NO.			
FINISH OR TREATMENT			
		SCALE	
SCHEMATIC - LOW VOLTAGE PWR SUPPLY REGULATORS			DIMENSIONS ARE IN INCHES TOL: .XX ± .015, .XXX ± .005, ANGLE ± W° UNLESS INDICATED OTHERWISE

SER. NO. 141-UP	640
SER. NO. 358-UP	630
NEXT ASSY	USED ON
ALFRED ELECTRONICS PALO ALTO, CALIFORNIA	
900718C	
SHEET 1	OF 1



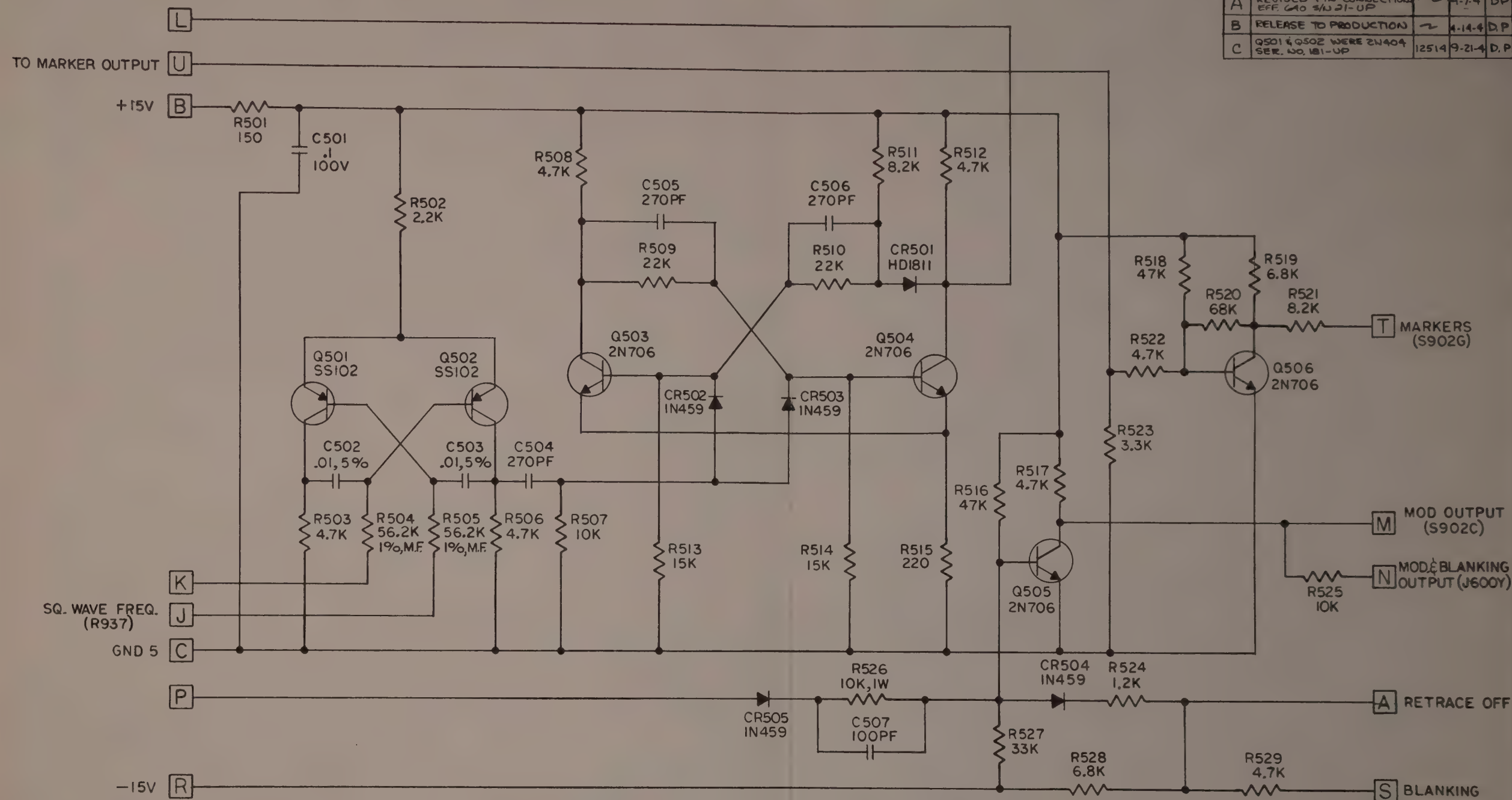
NOTES:

- UNLESS OTHERWISE SPECIFIED:
IA. ALL RESISTORS IN OHMS, 1/2W, 10%.
IB. ALL 1/2% AND 1% RESISTORS ARE METAL FILM TYPE.
IC. ALL CAPACITORS IN MICROFARADS, 500V.
- SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC400, ASSEMBLY NO. 950369.

ITEM	REQD	PART NO.	DESCRIPTION
LIST OF MATERIAL			
MATERIAL		DRAWN Dave Presley	DATE 9-27-63
		ENG Ralph Britton	10/1/63
MATERIAL STOCK NO.		PROD Tom Anderson	9-30-63
FINISH OR TREATMENT			
		SCALE	
		SCHEMATIC - MARKERS CIRCUIT	
		DIMENSIONS ARE IN INCHES TOL: .XX ± .015, .XXX ± .005, ANGLE ± W° UNLESS INDICATED OTHERWISE	

SER. NO. 11-UP	640
SER. NO. 76-UP	630
NEXT ASSY	USED ON
ALFRED ELECTRONICS PALO ALTO, CALIFORNIA	
900652C	
SHEET 1	OF 1

SYM	DESCRIPTION	NO.	DATE	BY
A	REVISED PIN CONNECTIONS EFF. 6/10/61-UP	1	4-7-64	DP
B	RELEASE TO PRODUCTION	2	4-14-64	DP
C	Q501 & Q502 WERE 2N404 SER. NO. 181-UP	12514	9-21-64	D.P.



NOTES

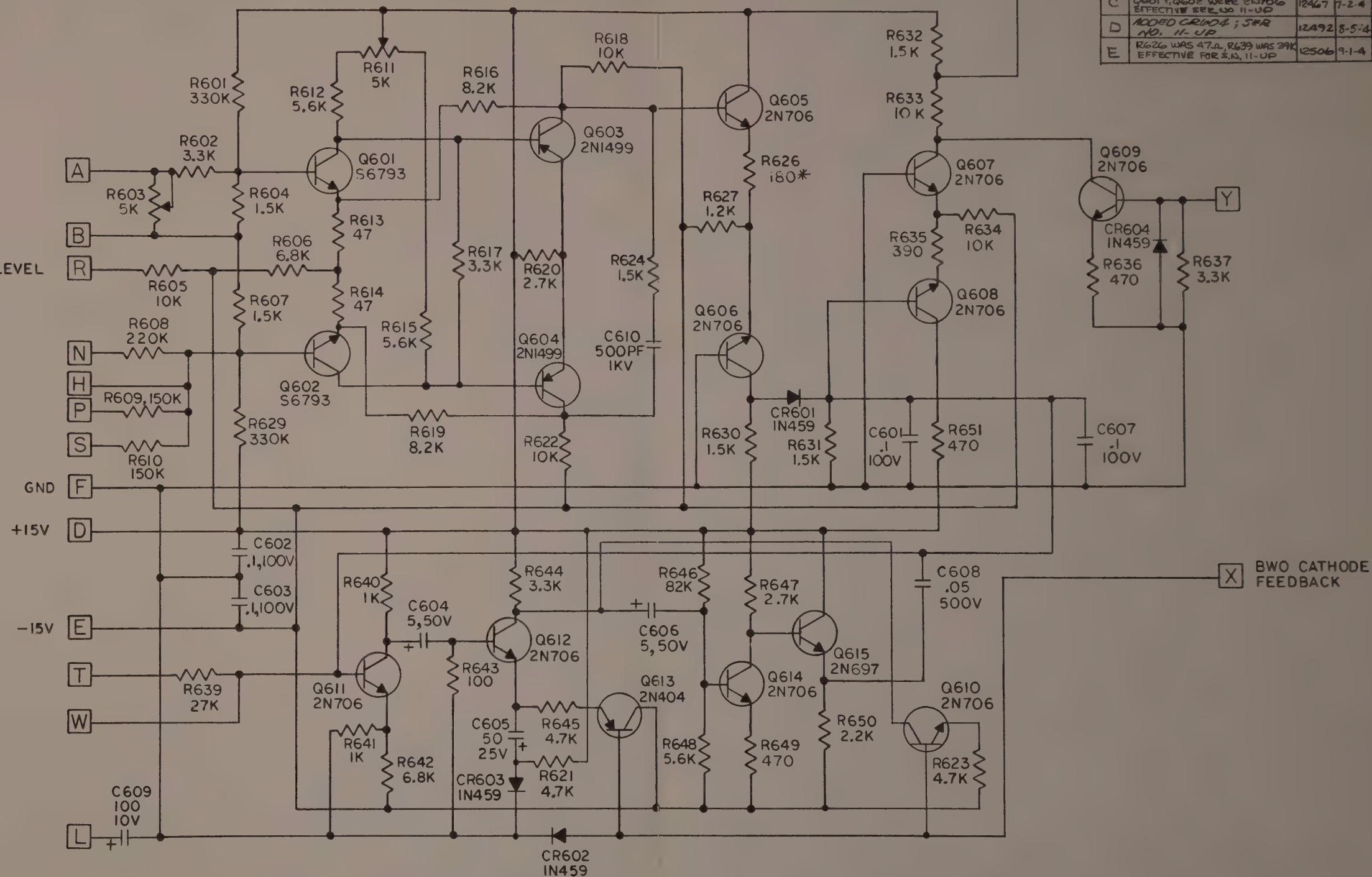
- UNLESS OTHERWISE SPECIFIED:
IA. ALL RESISTORS IN OHMS, 1/2W, 10%.
IB. ALL CAPACITORS IN MICROFARADS, 500V.
- SQUARE(□) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC500, ASSEMBLY NO. 950529.

ITEM	REQD	PART NO.	DESCRIPTION
LIST OF MATERIAL			
MATERIAL		DRAWN Dave Presley	DATE 12-18-63
		ENG [Signature]	9-19-64
		PROD [Signature]	4-14-68
MATERIAL STOCK NO.			
FINISH OR TREATMENT			
		SCALE	
		SCHEMATIC - SQUARE WAVE & MOD.	
		DIMENSIONS ARE IN INCHES TOL: .XX ± .015, .XXX ± .005, ANGLE ± W° UNLESS INDICATED OTHERWISE	

SER. NO. 11-UP	640
NEXT ASSY	USED ON
ALFRED ELECTRONICS PALO ALTO, CALIFORNIA	
900678C	
SHEET 1	OF 1

TO TRANSFER
OSCILLATOR [Z]

RF LEVEL

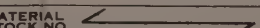
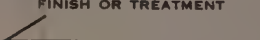


NOTES

- UNLESS OTHERWISE SPECIFIED:
IA. ALL RESISTORS IN OHMS, 1/2W, 10%.
IB. ALL CAPACITORS IN MICROFARADS.
- SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC600, ASSEMBLY NO. 950613.

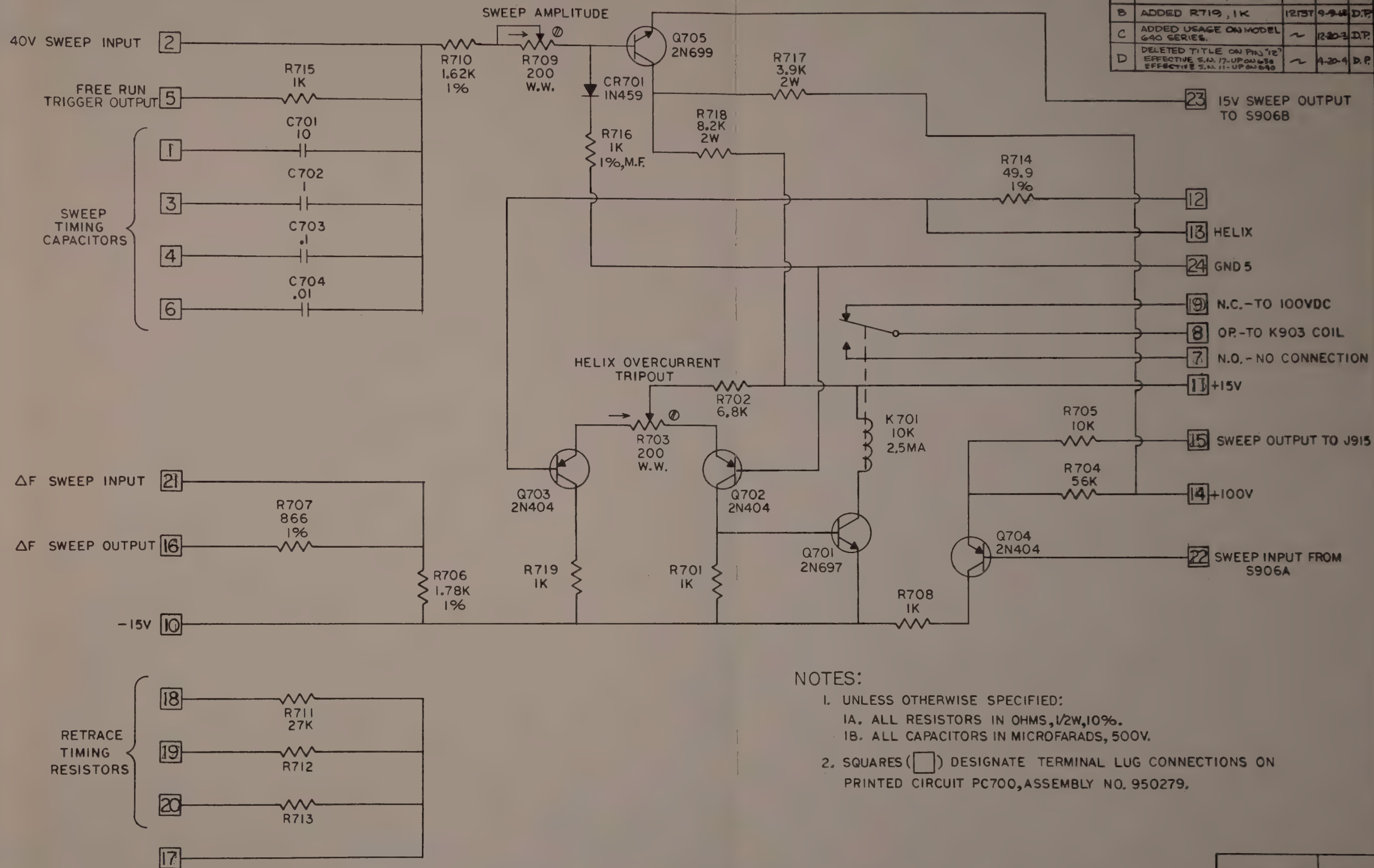
UNUSED NOS. R625, R628, R638.

* FACTORY SELECTED

ITEM	REQD	PART NO.	DESCRIPTION		SER.NO. 11-UP	640
LIST OF MATERIAL					NEXT ASSY	USED ON
MATERIAL			DRAWN	DATE	SCHEMATIC- LEVELER AMP.	
			Dave Presley	12-10-63		
			ENG	4-14-64		
			PROD	4-14-64		
MATERIAL STOCK NO.					ALFRED ELECTRONICS PALO ALTO, CALIFORNIA	
FINISH OR TREATMENT					900721C	
			SCALE		DIMENSIONS ARE IN INCHES TOL: .XX ± .015, .XXX ± .005, ANGLE ± W° UNLESS INDICATED OTHERWISE	
					SHEET	OF

SYM	DESCRIPTION	NO.	DATE	BY
A	APFD. FOR PRODUCTION THIS SCHEMATIC REPLACES 900676C, SER. NO. 11-UP	12447	6-19-64	D.P.
B	R639 WAS 27K, R640 WAS 4.7K, C602 WAS .1 100V. ADDED Q610 & R623. DELETED Q601. EFFECTIVE SER. NO. 11-UP	12452	7-2-64	D.P.
C	Q601, Q602 WERE 2N706. EFFECTIVE SER. NO. 11-UP	12467	7-2-64	D.P.
D	ADDED CR604; SER. NO. 11-UP	12492	8-5-64	V.I.
E	R624 WAS 4.7K, R639 WAS 27K. EFFECTIVE FOR S.N. 11-UP	12506	9-1-64	D.P.

SYM	DESCRIPTION	NO.	DATE	BY
A	APPD. FOR PRODUCTION	1	9-9-63	D.P.
B	ADDED R719, 1K	12137	9-9-63	D.P.
C	ADDED USAGE ON MODEL 640 SERIES.	1	12-20-63	D.P.
D	DELETED TITLE ON PIN "12" EFFECTIVE S.D. 17-UPON 640 EFFECTIVE S.D. 11-UPON 640	1	4-20-64	D.P.

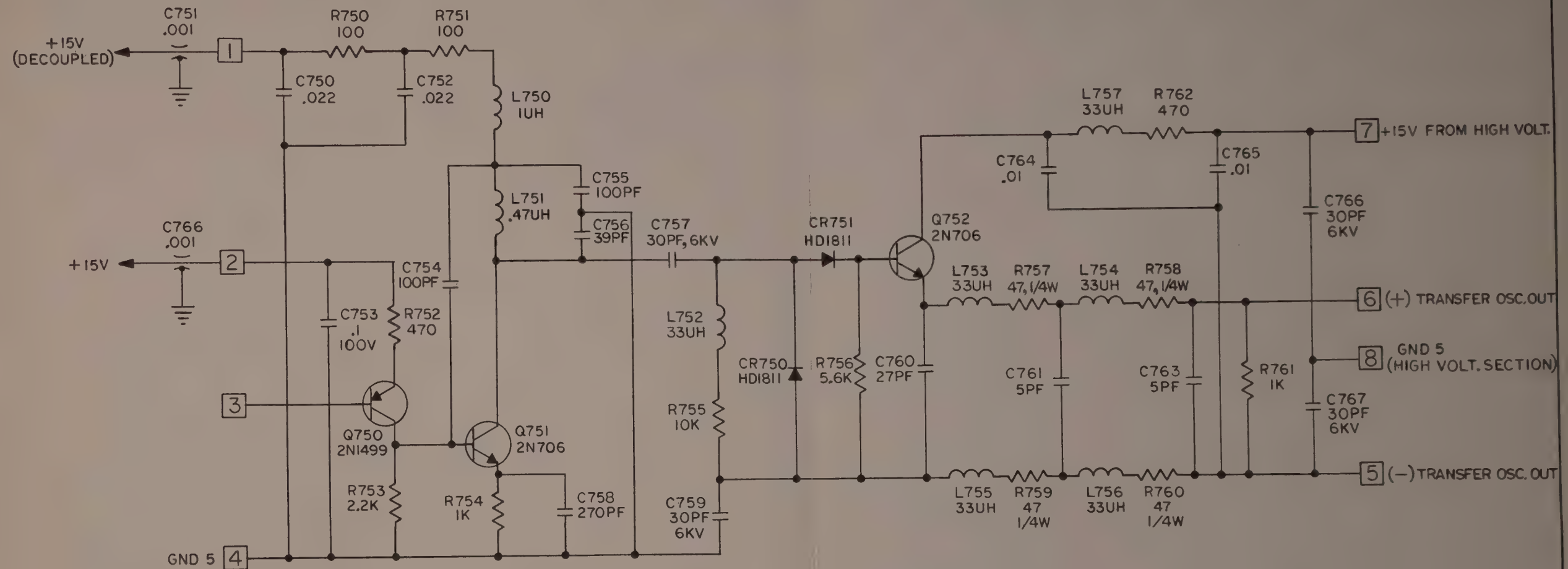


NOTES:

- UNLESS OTHERWISE SPECIFIED:
 - ALL RESISTORS IN OHMS, 1/2W, 10%.
 - ALL CAPACITORS IN MICROFARADS, 500V.
- SQUARES (□) DESIGNATE TERMINAL LUG CONNECTIONS ON PRINTED CIRCUIT PC700, ASSEMBLY NO. 950279.

ITEM	REQD	PART NO.	DESCRIPTION		SER. NO. 11-UP	640
LIST OF MATERIAL					SER. NO. 17-UP	630
MATERIAL			DRAWN	DATE	NEXT ASSY	USED ON
			Dave Presley	7-10-63	ALFRED ELECTRONICS PALO ALTO, CALIFORNIA	
			ENG	9-10-63		
			PROD	9-10-63		
MATERIAL STOCK NO.			SCHEMATIC — HELIX OVERCURRENT			
FINISH OR TREATMENT			DIMENSIONS ARE IN INCHES TOL: .XX ± .015, .XXX ± .005, ANGLE ± W° UNLESS INDICATED OTHERWISE			
			900598C			
			SHEET OF			

SYM	DESCRIPTION	NO.	DATE	BY
A	RELEASE TO PRODUCTION	~	4-14-64	DP

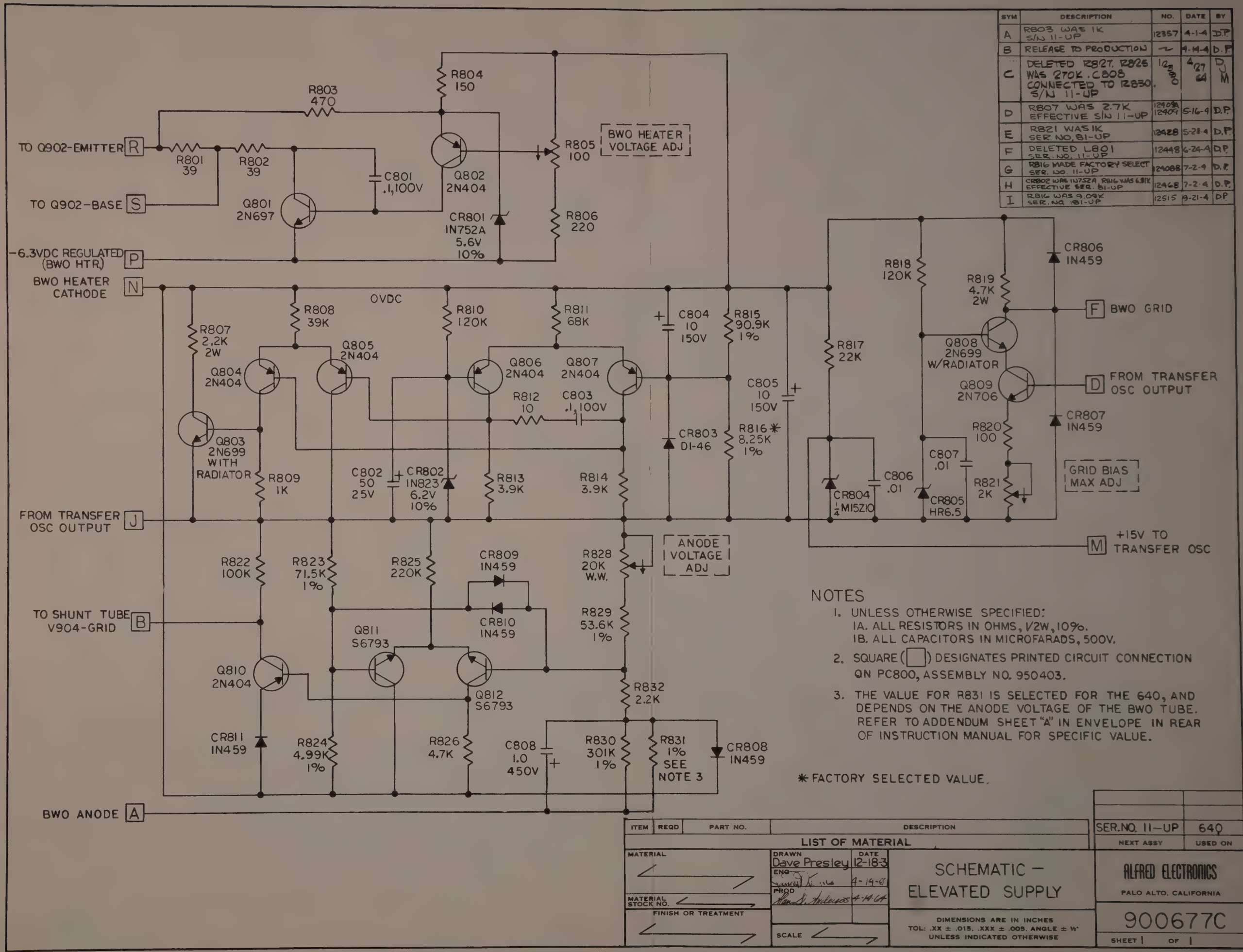


NOTES:

- UNLESS OTHERWISE SPECIFIED:
IA. ALL RESISTORS IN OHMS, 1/2W, 10%.
IB. ALL CAPACITORS IN MICROFARADS, 500V.
- SQUARE (□) DESIGNATES PRINTED WIRING BOARD CONNECTION ON ASSEMBLY NO. 950402.

C762 NOT USED

ITEM	REQD	PART NO.	DESCRIPTION	SER. NO. 11-UP	640
LIST OF MATERIAL				NEXT ASSY	USED ON
MATERIAL		DRAWN Dave Presley	DATE 12-19-63	SCHEMATIC - TRANSFER OSCILLATOR	
		ENG Stanley	4-14-64		
MATERIAL STOCK NO.		PROD Stanley	4-14-64	ALFRED ELECTRONICS PALO ALTO, CALIFORNIA	
FINISH OR TREATMENT					
		SCALE		900675C	
DIMENSIONS ARE IN INCHES TOL: .XX ± .015, .XXX ± .005, ANGLE ± W' UNLESS INDICATED OTHERWISE				SHEET 1 OF 1	

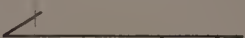
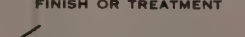


SYM	DESCRIPTION	NO.	DATE	BY
A	R803 WAS 1K S/N 11-UP	12357	4-14	D.P.
B	RELEASE TO PRODUCTION	12357	4-14	D.P.
C	DELETED R827, R828 WAS 270K. C808 CONNECTED TO R830. S/N 11-UP	12357 0	4-27 64	D.P.
D	R807 WAS 2.7K EFFECTIVE S/N 11-UP	12408 12409	5-16-4	D.P.
E	R821 WAS 1K SER. NO. 11-UP	12428	5-28-4	D.P.
F	DELETED L801 SER. NO. 11-UP	12448	6-24-4	D.P.
G	R816 MADE FACTORY SELECT SER. NO. 11-UP	12408	7-2-4	D.P.
H	CR802 WAS 1N752A. R816 WAS 6.2K EFFECTIVE SER. NO. 11-UP	12468	7-2-4	D.P.
I	R816 WAS 8.09K SER. NO. 11-UP	12515	9-21-4	D.P.

NOTES

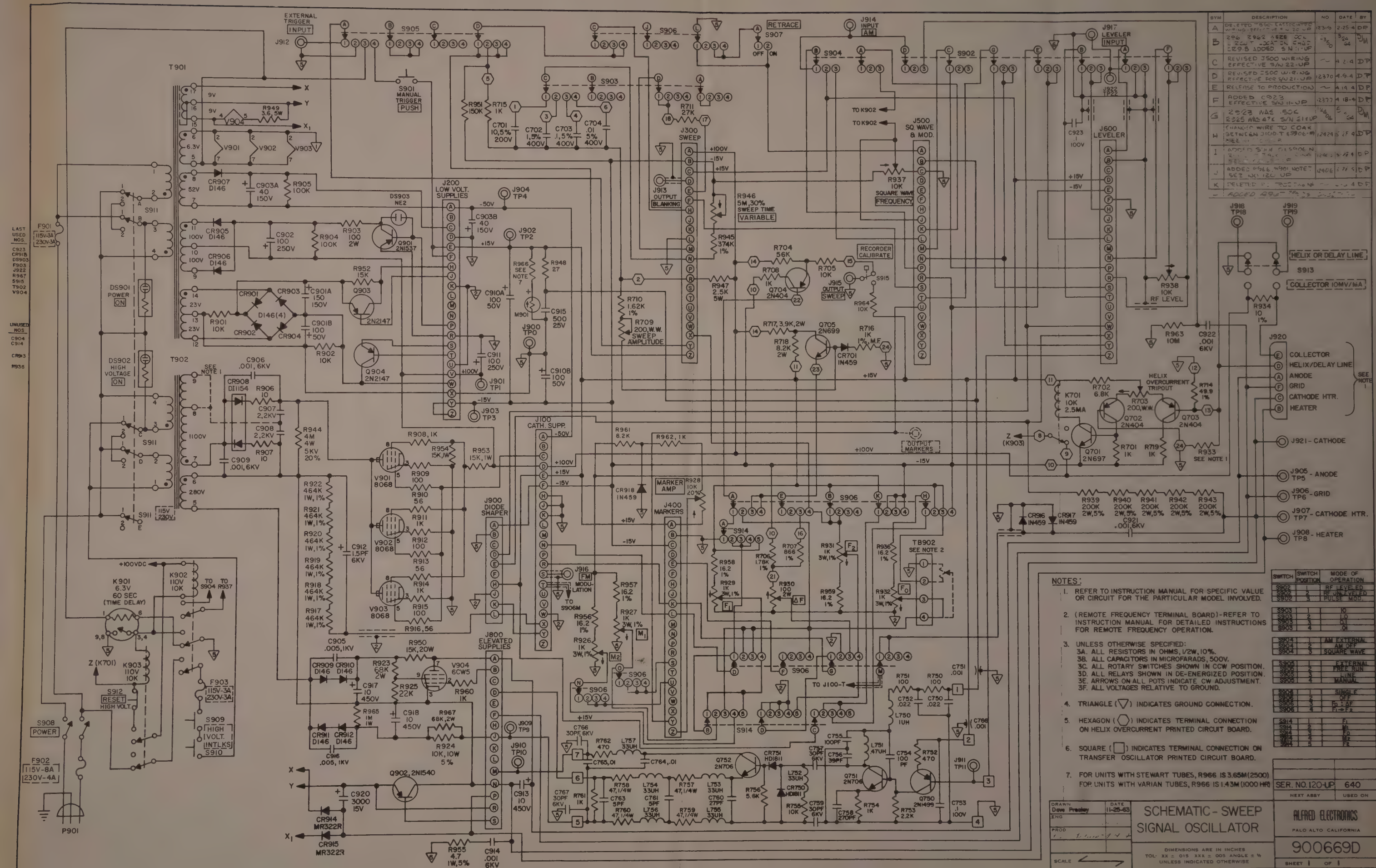
- UNLESS OTHERWISE SPECIFIED:
IA. ALL RESISTORS IN OHMS, 1/2W, 10%.
IB. ALL CAPACITORS IN MICROFARADS, 500V.
- SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION
ON PC800, ASSEMBLY NO. 950403.
- THE VALUE FOR R831 IS SELECTED FOR THE 640, AND
DEPENDS ON THE ANODE VOLTAGE OF THE BWO TUBE.
REFER TO ADDENDUM SHEET "A" IN ENVELOPE IN REAR
OF INSTRUCTION MANUAL FOR SPECIFIC VALUE.

* FACTORY SELECTED VALUE.

ITEM	REQD	PART NO.	DESCRIPTION		SER.NO. 11-UP	640
LIST OF MATERIAL					NEXT ASSY	USED ON
MATERIAL		DRAWN	DATE	SCHEMATIC - ELEVATED SUPPLY	ALFRED ELECTRONICS PALO ALTO, CALIFORNIA	
		Dave Presley	12-18-3			
MATERIAL STOCK NO.		ENG	4-14-6			
		PROD	4-14-6			
FINISH OR TREATMENT		SCALE		DIMENSIONS ARE IN INCHES TOL: .XX ± .015, .XXX ± .005, ANGLE ± W' UNLESS INDICATED OTHERWISE		
				900677C		
				SHEET OF		

LAST USED NOS.
C923
CR918
DS903
F903
J922
R967
S915
T902
V904

UNUSED NOS.
C904
C914
CR913
R935



Tube Replacement

All TWT and BWO tubes furnished in ALFRED instruments are available from ALFRED ELECTRONICS or the tube manufacturer for either warranty or out-of-warranty replacements. Current prices are given in the Replacement Tube Price List.

Tube Warranty

On ALFRED supplied TWT and BWO tubes used in catalog instruments, ALFRED ELECTRONICS extends the full warranty given by the tube manufacturer current at time of replacement and, in addition, offers the following minimum warranty:

"Tubes are warranted to meet specifications against defects in workmanship, materials, and construction for a period of one year or a rated number of heater hours, whichever expires first. If a defect occurs during the warranty period, a prorated adjustment will be made based on the list price of the tube and the percentage of rated heater operating hours or the one year period whichever results in lesser credit".

Rated hours are:

Type	Power	Warranty
TWTA	1 to 20 mw	2000 hours
TWTA	100 mw to 1 w	1000 hours
TWTA	2 to 10 w	500 hours
TWTA	(low N.F. 10 to 15 db)	1500 hours

Type	Frequency	Warranty
BWO	(Stewart - up to 12 Gc)	2500 hours
BWO	(Varian, 1 - 18 Gc)	1000 hours
BWO	(Varian, 18 - 40 Gc)	500 hours

If a tube should fail within the first 10% of warranty hours of heater operation and within two months after shipment, the tube will be replaced at no charge.

RETURN AUTHORIZATION

TO OBTAIN WARRANTY CREDIT THE TUBE SERVICE REPAIR OR CREDIT ADJUSTMENT WITHOUT WRITTEN AUTHORIZATION AND ACCOMPANYING SERVICE REPORT.

Return Procedure

In case of tube or instrument failure, please contact the factory or your local sales representative for advise or authorization to return either the tube or the instrument to the factory. NO TUBE OR INSTRUMENT WILL BE ACCEPTED FOR REPAIR OR CREDIT ADJUSTMENT WITHOUT WRITTEN AUTHORIZATION AND ACCOMPANYING SERVICE REPORT.

When the authorization is received, pack the tube in a rigid container (use original carton if available) at least 4" larger than the tube in each dimension. Wrap the tube with 1/4" of soft padding material and heavy kraft paper before placing in container. Pack at least 2" of resilient dunnage such as rubberized hair, foam, or similar shock absorbing material completely all around the tube. Mark the container "FRAGILE" and ship PREPAID via air freight, air express or rail express. Do not ship via parcel post or air parcel post since experience has shown that fragile items are more apt to be damaged when shipped via these methods. At least 6" of rubberized hair (or equivalent shock absorbing material) is required for an instrument.

Repairable Tube

If the returned tube is found to be repairable, the user will be asked to issue a purchase order for repair charges determined by the original tube manufacturer. In general, the repair will be at no cost if the tube is in warranty and there is no evidence of misuse or abnormal conditions of operation.

In-warranty Failure of BWO Tubes

If a BWO fails during the warranty period, please issue a purchase order for a new BWO tube at the tube list price and return the defective BWO tube. The defective tube will be examined by the tube manufacturer and if the failure is caused by tube malfunction, warranty credit will be issued. For warranty credit based on month of service credit will be granted based on date when the defective tube is received at plant.

Warranty Credit

Any applicable credit allowed under the terms of this warranty applies only toward the future purchase of a replacement tube from ALFRED ELECTRONICS. Cash settlements will not be made. In terms of this warranty, a replacement tube must be the same type as that on which credit is allowed. Credit for one tube only may be applied toward the purchase of a single replacement tube. Warranty credit remains in effect for a maximum of 6 months from date ALFRED ELECTRONICS notifies the customer. All credits will be based on the purchase price of the tube which prevails at the time the order for a replacement tube is received by ALFRED ELECTRONICS.

BWO RF CABLES

RF OUTPUT CABLE MUST ACCOMPANY BWO TUBES returned for warranty credit, repair, or replacement. If rf output cable is NOT returned, the cable price is added to the normal BWO repair or replacement charge. For prices see Replacement Tube Price List.

Special Conditions

If a returned tube or instrument proves not to be defective after test and evaluation at ALFRED ELECTRONICS, the tube or instrument will be returned at the customer's expense.

The final determination as to whether the tube failed in normal operation thereby bringing it under the applicable warranty or whether the tube was misused thereby excluding it from application of the warranty provisions lies solely with the tube manufacturer.

Data, warranty credit, and prices subject to change without notice.

3/24/64

ALFRED ELECTRONICS

Service Report

Instrument Model _____ Serial No. _____ Date Received _____

TW/BWO Tube Type _____ Serial No. _____ Date Received _____

Date First Tested _____ Date Placed in Service _____ Date of Failure _____

Total Number of Hours of TWT/BWO Heater Operation _____

1. Was operation normal just prior to failure? Yes _____ No _____

2. If not, what was done to adjust it? _____

3. Has proper cooling been maintained during tube operation? _____

4. Did helix overcurrent tripout occur? _____

5. Was environment normal? (specify) _____

6. Symptoms - (describe failure) _____

7. Operating conditions at time of failure (indicate any unusual conditions) _____

8. Name of person to contact regarding evaluation of failure _____

Telephone No. _____

Signature _____

Title _____

Date _____

Tube Replacement

All TWT and BWO tubes furnished in ALFRED instruments are available from ALFRED ELECTRONICS or the tube manufacturer for either warranty or out-of-warranty replacements. Current prices are given in the Replacement Tube Price List.

Tube Warranty

On ALFRED supplied TWT and BWO tubes used in catalog instruments, ALFRED ELECTRONICS extends the full warranty given by the tube manufacturer current at time of replacement and, in addition, offers the following minimum warranty:

"Tubes are warranted to meet specifications against defects in workmanship, materials, and construction for a period of one year or a rated number of heater hours, whichever expires first. If a defect occurs during the warranty period, a prorated adjustment will be made based on the list price of the tube and the percentage of rated heater operating hours or the one year period whichever results in lesser credit".

Rated hours are:

Type	Power	Warranty
TWTA	1 to 20 mw	2000 hours
TWTA	100 mw to 1 w	1000 hours
TWTA	2 to 10 w	500 hours
TWTA	(low N.F. 10 to 15 db)	1500 hours

Type	Frequency	Warranty
BWO	(Stewart - up to 12 Gc)	2500 hours
BWO	(Varian, 1 - 18 Gc)	1000 hours
BWO	(Varian, 18 - 40 Gc)	500 hours

If a tube should fail within the first 10% of warranty hours of heater operation and within two months after shipment, the tube will be replaced at no charge.

RETURN AUTHORIZATION

TO OBTAIN WARRANTY CREDIT THE TUBE SERVICE REPORT MUST BE COMPLETED AND RETURNED WITH THE TUBE.

Return Procedure

In case of tube or instrument failure, please contact the factory or your local sales representative for advise or authorization to return either the tube or the instrument to the factory. NO TUBE OR INSTRUMENT WILL BE ACCEPTED FOR REPAIR OR CREDIT ADJUSTMENT WITHOUT WRITTEN AUTHORIZATION AND ACCOMPANYING SERVICE REPORT.

When the authorization is received, pack the tube in a rigid container (use original carton if available) at least 4" larger than the tube in each dimension. Wrap the tube with 1/4" of soft padding material and heavy kraft paper before placing in container. Pack at least 2" of resilient dunnage such as rubberized hair, foam, or similar shock absorbing material completely all around the tube. Mark the container "FRAGILE" and ship PREPAID via air freight, air express or rail express. Do not ship via parcel post or air parcel post since experience has shown that fragile items are more apt to be damaged when shipped via these methods. At least 6" of rubberized hair (or equivalent shock absorbing material) is required for an instrument.

Repairable Tube

If the returned tube is found to be repairable, the user will be asked to issue a purchase order for repair charges determined by the original tube manufacturer. In general, the repair will be at no cost if the tube is in warranty and there is no evidence of misuse or abnormal conditions of operation.

In-warranty Failure of BWO Tubes

If a BWO fails during the warranty period, please issue a purchase order for a new BWO tube at the tube list price and return the defective BWO tube. The defective tube will be examined by the tube manufacturer and if the failure is caused by tube malfunction, warranty credit will be issued. For warranty credit based on month of service credit will be granted based on date when the defective tube is received at plant.

Warranty Credit

Any applicable credit allowed under the terms of this warranty applies only toward the future purchase of a replacement tube from ALFRED ELECTRONICS. Cash settlements will not be made. In terms of this warranty, a replacement tube must be the same type as that on which credit is allowed. Credit for one tube only may be applied toward the purchase of a single replacement tube. Warranty credit remains in effect for a maximum of 6 months from date ALFRED ELECTRONICS notifies the customer. All credits will be based on the purchase price of the tube which prevails at the time the order for a replacement tube is received by ALFRED ELECTRONICS.

BWO RF CABLES

RF OUTPUT CABLE MUST ACCOMPANY BWO TUBES returned for warranty credit, repair, or replacement. If rf output cable is NOT returned, the cable price is added to the normal BWO repair or replacement charge. For prices see Replacement Tube Price List.

Special Conditions

If a returned tube or instrument proves not to be defective after test and evaluation at ALFRED ELECTRONICS, the tube or instrument will be returned at the customer's expense.

The final determination as to whether the tube failed in normal operation thereby bringing it under the applicable warranty or whether the tube was misused thereby excluding it from application of the warranty provisions lies solely with the tube manufacturer.

Data, warranty credit, and prices subject to change without notice.

3/24/64

ALFRED ELECTRONICS

Service Report

Instrument Model _____ Serial No. _____ Date Received _____

TW/BWO Tube Type _____ Serial No. _____ Date Received _____

Date First Tested _____ Date Placed in Service _____ Date of Failure _____

Total Number of Hours of TWT/BWO Heater Operation _____

1. Was operation normal just prior to failure? Yes _____ No _____

2. If not, what was done to adjust it? _____

3. Has proper cooling been maintained during tube operation? _____

4. Did helix overcurrent tripout occur? _____

5. Was environment normal? (specify) _____

6. Symptoms - (describe failure) _____

7. Operating conditions at time of failure (indicate any unusual conditions) _____

8. Name of person to contact regarding evaluation of failure _____

Telephone No. _____

Signature _____

Title _____

Date _____

SHIPMENT DAMAGE CLAIM

The instrument should be tested as soon as it is received. If it fails to operate properly or is damaged in any way, a claim must be filed with the carrier. Have carrier agent inspect damage to instrument and packing crate and forward us a copy of his written report. You will then be advised of replacement or repair arrangements and disposition of the equipment. Please include model number, type number and serial number when referring to this instrument for any reason.

WARRANTY

ALFRED products are warranted against defects in workmanship and materials. This warranty is limited to repair or replacement of products or parts (except tubes, transistors, and batteries) which prove defective within one year after delivery to original purchaser. ALFRED ELECTRONICS is not liable for consequential damage.

If any fault develops:

1. Notify us, giving full details of the difficulty, including the model number, type number and serial number. Upon receipt of this information, you will be sent service instructions or shipping data.
2. Upon receipt of shipping instructions, forward the instrument prepaid and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins when instrument is not covered by this warranty.

PACKING

The instrument should be packed in the original carton. If unusable or not available, use a wooden box with approximately three inches of excelsior or other shock-absorbing material surrounding the instrument. If desired, packing services of a local transfer and storage company may be employed.



THIS ENVELOPE CONTAINS:
ADDENDUM SHEETS
TEST DATA

